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92-00195/

ULTRAFILTRATION FIELD PILOT TESTING
FOR THE
TREATMENT OF PRODUCED WATER

Volume I

Final Report

By

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Work on this project was conducted under the auspices of the Department of Energy, Mines and Resources.

DSS File Number: 03SQ.23440-7-9165

DSS Contract Number: 23440-7-9165/01-SQ

EMR Scientific Authority: Brian Farnand

MICROMEDIA

109 pp

File No. CO874073

June 28, 1990

ZENON

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28 June 1990

File No. C0874073

Angela Humphreys
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Dear Mrs. Humphreys:

RE:DSS File No. 03SQ,23440-7-9165,
Membrane Process Testing for Oil Field Produced Water Treatment

We are pleased to submit three copies of our final report for the above referenced contract. The submital of this report completes our contractual requirements based on the Terms of Reference for this contract.

We are encouraged by the results of the study and hope CANMET will take an interest in further developing membrane technology as applied to produced water treatment.

If you have any questions or concerns, please do not hesitate to contact the undersigned.

Yours truly,

R.P. Canning

R.P. Canning
Manager, Process Engineering

RPC/cjp

encl.

ABSTRACT

Steam stimulated enhanced oil recovery (EOR) methods generate large volumes of an oil-water emulsion known as produced water. Opportunities exist for the treatment of produced water for recovery and reuse as boiler feed water. Ultrafiltration is a potential alternative treatment method to conventional technology (Skim Tank, Induced Gas Flotation, Sand Filter) currently used for removing emulsified oil from produced water.

An on-site pilot test programme evaluated produced water ultrafiltration at two EOR in-situ operations in Western Canada. An explosion proof ZENON ultrafiltration pilot system was installed and operated on site by ZENON personnel. Operating conditions were fixed at a module inlet pressure of 415 kPa, a feed flow rate of 105 L/min, and a temperature of 73°C. Most of the testing was conducted on produced water accepted from the Skim Tank influent stream, where the concentration of total oil (TO) varied within the approximate range of 100 mg/L to 2000 mg/L. Produced water feed characteristics were variable and often changed rapidly throughout most of the testing. Batch and continuous modes of equipment operation were investigated, using three different tubular cross-flow filtration membrane types, in an "8-tube" in series configuration.

Each membrane type (HEM, HST, HSC) demonstrated complete separation of emulsified oil from the produced water. In general, the membranes rejected approximately 85% of the total oil (TO) and 20% of the total dissolved oil (TDO). Virtually 100% of total suspended matter (TSM) and 0% of total dissolved solids (TDS) were rejected by the membranes. The quality of ultrafiltration permeate was comparible to, if not better than, conventional produced water treatment. In addition, the quality of membrane separation remained relatively constant throughout testing, despite large changes in feed concentrations. This insensitivity demonstrates the excellent potential for ultrafiltration to dampen EOR treatment system upsets.

Membrane treatment productivity was dependent on feed conditions and membrane run time exposure. Membrane type had little influence on productivity. Average membrane flux rates were typically in the range of 50 LMH to 300 LMH. The membrane tested for the longest run time had an average flux of 122 LMH, standard deviation of 101, over 1694 operating hours. Large flux deviations were noted for all membranes and were the result of frequent cleanings and decreasing productivity caused by membrane fouling. Cleaning efforts throughout the test programme indicated

incomplete cleaning of the membrane and therefore a gradual decrease in flux over time. Foulant was visible on all the membrane surfaces viewed after tested, and it is speculated to be related to clay in the produced water. The presence of clay in produced water poses fouling potential in ultrafiltration, since it is speculated the clay draws oil out of emulsion to create an oily solid having an attraction to the membrane surface.

An economic assessment indicates ultrafiltration requires a flux of 85 LMH to be cost competitive with conventional technology. Based on average flux rates, most of the membranes tested met this flux criterion. However, long term flux potential is uncertain since none of the membranes clearly reached a stable flux level before the end of testing. An approximate projection of results would suggest fluxes of no greater than 50 LMH could be achieved at either of the two sites tested. This projection indicates current membrane technology would not be competitive with conventional technology at EOR sites were clay is problem, such as the two sites tested. However, membrane technology indicates excellent potential where clay is not present in the produced water, or present in low concentrations.

Further development of ultrafiltration technology will increase its economic attractiveness. The development of a hybrid membrane configuration resistant to high temperature and aggressive solvents will improve flux performance and membrane cleanability, as well as increased the number of EOR sites where ultrafiltration can be a feasible alternative to conventional technology.

EXTRAIT

Les méthodes d'extraction de pétrole par injection forcée de vapeur produisent un grand volume d'émulsions composées de pétrole et d'eau. Il est possible de traiter ces émulsions et de recycler l'eau pour le chauffage des chaudières. L'ultrafiltration pourrait être l'alternative à la méthode tradionnelle utilisée pour la séparation du pétrole.

Un programme d'essai a évalué cette méthode d'ultrafiltration dans deux centres d'extraction du pétrole par injection forcée de vapeur de l'Ouest du Canada. Une pilote d'ultrafiltration ZENON, à l'épreuve des explosions, a été installée et opérée sur place par le personnel de ZENON. Les paramètres de fonctionnement furent délimités à une pression d'entrée de 415 kPa, un écoulement de 105 L/min, et une température de 73°C. La plus grande partie de l'évaluation eut lieu sur des produits en provenance de la cuve d'écrémage, où la concentration des huiles totales variait entre 100 mg/L, à 2000 mg/L. Les caractéristiques de l'émulsion étaient soumises à des changements rapides durant toute l'évaluation. L'enquête porta sur des modes de traitement par lots et continus qui utilisaient trois différentes membranes poreuses tubulaires, dans une configuration de 8 tubes en série.

Chaque type de membrane (HEM, HST, HSC), effectuait une séparation complète des huiles contenues dans l'émulsion. En général, les membranes rejetèrent approximativement 85% des huiles totales et 20% des huiles solubles. Pratiquement 100% des matières en suspension et 0% des solides dissous furent rejetés par les membranes. Le pouvoir filtrant de l'ultrafiltration fut comparable, ou supérieur, au traitement des émulsions par la méthode traditionnelle. De plus, le pouvoir filtrant des membranes resta constant durant toute l'évaluation, malgré des grandes fluctuations dans le niveau de concentration de l'émulsion. Ce fait démontre le grand potentiel de l'ultrafiltration pour réduire l'effet des changements soudains inhérents à l'extraction du pétrole par injection de vapeur.

Le rendement des membranes fut une fonction des caractéristiques de l'émulsion et de la durée de service. Le type de membrane utilisée eut trés peu d'effet sur le rendement. Les flux d'émulsions passant par les membranes varièrent entre 50 L/m^2/h et 300 L/m^2/h. La membrane évaluée durant la plus grande période de temps, produisit un flux moyen de 122 L/m^2/h, une déviation standard de 101, durant 1694 heures de fonctionnement. De grandes variations de flux observées pour toutes les membranes, furent le résultat de nettoyages fréquents et de diminutions de rendement, dûes à l'engorgement des membranes. Les efforts exercés pour accomplir les nettoyages durant le programme d'évaluation résultèrent en un nettoyage incomplet de la membrane, ce qui eut, à la longue, pour résultat une diminution des flux. Après l'évaluation, de

dépôts, attribués à la présence d'argile dans l'émulsion, étaient présents sur toute la surface des membranes. La présence d'argile dans l'émulsion crée un problème d'encrassement de l'ultrafiltration, car on pense que l'argile absorbe le pétrole de l'émulsion pour former une masse solide qui adhère à la membrane.

Une étude économique indique que l'ultrafiltration doit produire un écoulement de 85 L/m^2/h pour être financièrement concurrentielle avec la technologie tradtionnelle. En prenant comme base des flux moyens, la plupart des membranes évaluées répondent à ce critère. La performance à long terme est cependant incertaine, puisqu'aucune des membrane produisit un flux stable avant le fin de l'évaluation. Une interprétation approximative des résultats fait penser que des écoulements n'atteignant pas plus de 50 L/m^2/h, pourraient être réalisés aux deux sites où l'évaluation eut lieu. Cette étude indique que les membranes courantes ne peuvent pas concurrencer les méthodes de traitement traditionnelles là où, comme c'était le cas aux deux sites évalués, de l'argile est présente. Les membranes gardent cependant leur grand potentiel, lorsque l'argile est absente de l'émulsion, ou y est trouvée en petites quantités.

Les développements technologiques de l'ultrafiltration accroîtront on intérêt économique. Le développement d'une membrane résistante aux températures elevées et aux solvants améliorerait les flux et le nettoyage, et augmenterait le nombre de sites où l'ultrafiltration peut être considéré comme alternative aux méthodes traditionnelles.

ACKNOWLEDGEMENTS

We wish to thank Shell Canada and Amoco Canada for providing an in-situ enhanced oil recovery operation for the testing of produced water ultrafiltration. We also wish to thank them for their generous contribution of technical and analytical support throughout the project.

In addition, we thank Environment Canada for contributing to on-site hookups at the Amoco site as well as diligent analytical support.

TABLE OF CONTENTS

Page No.

Abstract
Acknowledgements
Table of Contents
List of Figures
List of Plates
List of Tables

1.0 **Introduction** 1
- 1.1 Background 1
- 1.2 Objectives 4

2.0 **Experimental Plan** 5
- 2.1 Field Test Sites 5
- 2.2 Membranes 5
- 2.3 Pilot Test Equipment 8
  - 2.3.1 Design Objectives 8
  - 2.3.2 Process Description 9
- 2.4 Membrane Cleaning 12
- 2.5 Membrane Evaluation 13
- 2.6 Sample Analysis 14

3.0 **Site "A" Results and Discussion** 15
- 3.1 Feed Characterisation 15
- 3.2 Experimental 15
- 3.3 Results 17
  - 3.3.1 Stage I 18
  - 3.3.2 Stage II 27
  - 3.3.3 Stage III 34
  - 3.3.4 Membrane Surface Fouling 39
- 3.4 Site "A" Summary 40

4.0 **Site "B" Results and Discussion** 46
- 4.1 Feed Characterisation 46
- 4.2 Experimental 46
- 4.3 Results 48
  - 4.3.1 Stage IV 48
  - 4.3.2 Stage V 57
  - 4.3.3 Membrane Surface Fouling 70

Table of Contents (cont'd)

Page No.

4.4 Site "B" Summary 75

5.0 **Economic Assessment** 83
5.1 Design Basis 83
5.2 Cost 83
5.3 Discussion 86

6.0 **Conclusions and Recommendations** 90
6.1 Conclusions 90
6.2 Recommendations 92

7.0 **References** 94
Glossary
Abbreviations

APPENDIX A Site "A" - Operating Data
APPENDIX B Site "A" - Analytical Data
APPENDIX C Site "B" - Operating Data
APPENDIX D Site "B" - Analytical Data
APPENDIX E Analytical Methods
APPENDIX F Emulsion Characterisation
APPENDIX G Ultrafiltration Equipment and Operation
APPENDIX H Cost Breakdown of Convention and Membrane Based Treatment

LIST OF FIGURES

Page No.

1-1 Conventional Produced Water Treatment Process 2

1-2 Potential Membrane Treatment Process 2

2-1 Process Flow Schematic of Site "A" Enhanced Oil Recovery Operation 6

2-2 Process Flow Schematic of Site "B" Enhanced Oil Recovery Operation 6

2-3 Produced Water Ultrafiltration Pilot Test System 11

3-1 Site "A," Stage I, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO), and Total Suspended Matter (TSM) Versus Run Time 19

3-2 Site "A," Stage I, Membrane Feed Concentration of Total Oil and HEM-01, HST-01, HST-03, and HSC-01 Permeate Concentration of Total Oil Versus Run Time 20

3-3 Site "A," Stage I, Flux Versus Run Time for the HEM-01 Membrane 22

3-4 Site "A," Stage I, Flux Versus Run Time for the HST-01, HST-03, and HSC-01 Membrane 23

3-5 Site "A," Stage II, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO), and Total Suspended Matter (TSM) Versus Run Time 28

3-6 Site "A," Stage II, Membrane Feed Concentration of Total Oil and HEM-02 and HST-02 Permeate Concentration of Total Oil Versus Run Time 30

3-7 Site "A," Stage II, Flux Versus Run Time for the HEM-02 and HST-02 Membranes 31

3-8 Site "A," Stage III, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO), and Total Suspended Matter (TSM) Versus Run Time 35

3-9 Site "A," Stage III, Membrane Feed Concentration of Total Oil (TO) and HEM-06 Permeate Concentration of Total Oil (TO) Versus Run Time 37

3-10 Site "A," Stage III, Flux Versus Run Time for the HEM-04 and HEM-06 Membranes 38

3-11 Site "A," Average HEM Flux and HEM Permeate Concentration of Total Oil Versus Membrane Feed Concentration of Total Oil (HEM-01 and HEM-06 data) 44

4-1 Site "B," Stage IV, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO), and Total Suspended Matter (TSM) Versus Run Time 49

4-2 Site "B," Stage IV, Membrane Feed Concentration of Total Oil and HEM-07, HEM-09, HST-04, and HSC-03 Permeate Concentration of Total Oil Versus Run Time 52

4-3 Site "B," Stage IV, Flux Versus Run Time for the HEM-07 and HEM-08 Membranes 53

LIST OF FIGURES

Page No.

4-4 Site "B," Stage IV, Flux Versus Run Time for the HSC-03 and HST-04 Membranes 54
4-5 Site "B," Stage V, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO) and Total Suspended Matter (TSM) Versus Run Time 58
4-6 Site "B," Stage V, Membrane Feed Concentration of Total Oil and HEM-07, HEM-08, HEM-09, HST-04, HST-05, and HSC-04 Permeate Concentration of Total Oil Versus Run Time 62
4-7 Site "B," Stage V, Flux Versus Run Time for the HEM-07, HEM-08, and HEM-09 Membranes 63
4-8 Site "B," Stage V, Flux Versus Run Time for the HST-04, HST-05, and HSC-04 Membranes 64
4-9 Site "B," Stage V, Flux Versus Run Time for the New Membrane Types Used in Parallel Bench Scale Tests 69
4-10 Site "B," HEM-07 Flux and HEM-07 Permeate Concentration of Total Oil Versus Membrane Feed Concentration of Total Oil 77
4-11 Site "B," Stage IV and V, HEM-07 Flux and Membrane Feed Concentration of Total Dissolved Solids (TDS) Versus Run Time 79
4-12 Site "B," Stage IV and V, HEM-07 Flux and Membrane Feed Concentration of Total Suspended Matter (TSM) Versus Run Time 80
5-1 Process Flow Schematic for Cost Assessment of Conventional Produced Water Treatment 84
5-2 Process Flow Schematic for Cost Assessment of Membrane Based Produced Water Treatment 84
5-3 Yearly Costs for Conventional and Membrane Based Produced Water Treatment Processes (10 Year Amortisation of Capital), with Membrane Replacement Costs for 0.5, 1, 2, and 3 Years Versus Membrane Flux Rate 85
5-4 Site "B," Stages IV and V, Flux Versus Run Time for the HEM-07 Membrane 88

LIST OF PLATES

		Page No.
3-1	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of an Unused HEM Membrane. Total Run Time of 0 Hours.	41
3-2	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HEM-01 Membrane. Total Run Time of 34 Hours.	41
3-3	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HEM-04 Membrane. Total Run Time of 0.4 Hours.	42
3-4	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HST-03 Membrane. Total Run Time of 20 Hours.	42
4-1	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of an Unused HEM Membrane. Total Run Time of 0 Hours.	71
4-2	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HEM-07 Membrane. Total Run Time of 1694 Hours.	71
4-3	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HEM-08 Membrane. Total Run Time of 544 Hours.	72
4-4	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HST-04 Membrane. Total Run Time of 875 Hours.	72
4-5	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HST-05 Membrane. Total Run Time of 265 Hours.	73
4-6	Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HSC-04 Membrane. Total Run Time of 336 Hours.	73

LIST OF TABLES

		Page No.
2-1	Membrane Characterisation Data	5
2-2	Approximate Ultrafiltration Operating Conditions for Each Module Position	12
3-1	Description of Test Stages at Site "A"	15
3-2	Site "A," Stage I, Average Flux and Rejection Summary	21
3-3	Site "A," Stage II, Average Flux and Rejection Summary	29
3-4	Site "A," Stage III, Average Flux and Rejection Summary	36
4-1	Description of Test Stages at Site "B"	46
4-2	Site "B," Stage IV, Average Flux and Rejection Summary	51
4-3	Site "B," Stage V, Average Flux and Rejection Summary	61
5-1	Capital and Operating Costs for Conventional and Membrane Based Processes for Oil Removal	86
6-1	Typical Membrane Total Oil Removal at Site "A" and Site "B"	90

1.0 INTRODUCTION

1.1 Background

Steam stimulated enhanced oil recovery (EOR) is a common practice for bitumen oil reserves in Western Canada. The recovery method requires large volumes of water for steam generation and injection into the oil formation. As a result of this method, large volumes of water contaminated with oil and other material are produced. This material is termed "produced water." Since many oil recovery operations are located in environmentally sensitive areas where water is scarce, efforts have been directed in recent years to develop efficient and economical processes for the treatment of produced water for boiler feed water recycle.

Most steam stimulated EOR operations separate water from oil in a conventional manner. Generally, EOR production fluid is treated in a free water knock out (FWKO) tank and high temperature separator (HTS) to recover as much of the bulk phase oil as possible. The remaining water (produced water) from the FWKO and HTS is generally combined and sent to a Skim Tank, where some additional oil is removed and recycled back to the recovery process. The remaining water is often disposed of by deep well injection or in some cases further treated for recycle. Additional water treatment for recycle might involve induced gas flotation (IGF) and sand filtration; for the removal of suspended solids and oil, followed by warm lime softening and ion exchange; as a final polishing step before sending the treated water to steam boilers for reuse.

Conventional oily water treatment processes have drawbacks. They are expensive because of the several unit operation and chemical additives are required to complete the separation. Treated effluent quality is difficult to control and results in expensive operation and maintenance costs. Figure 1-1 illustrates the conventional produced water treatment solution.

FIGURE 1-1

Conventional Produced Water Treatment Process

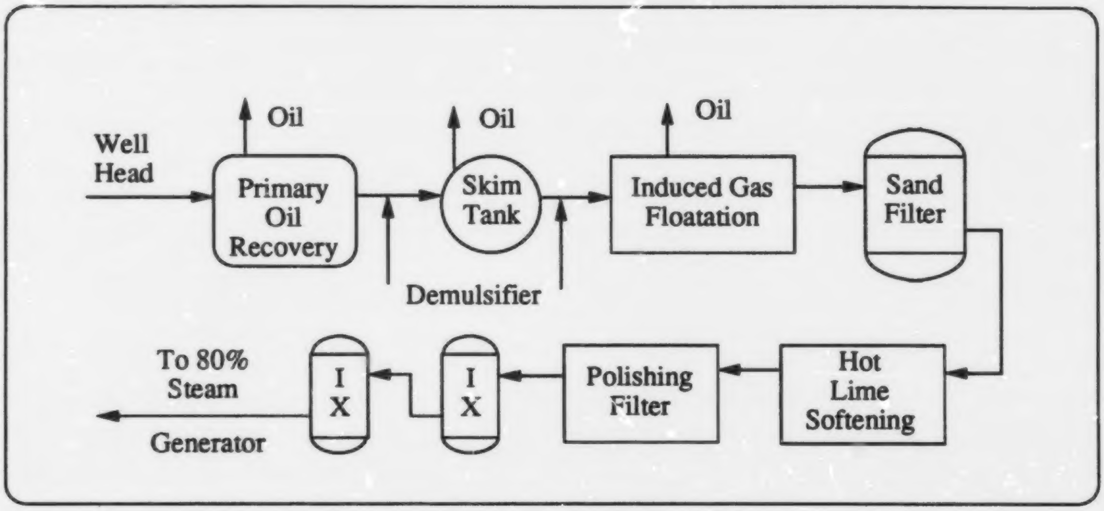
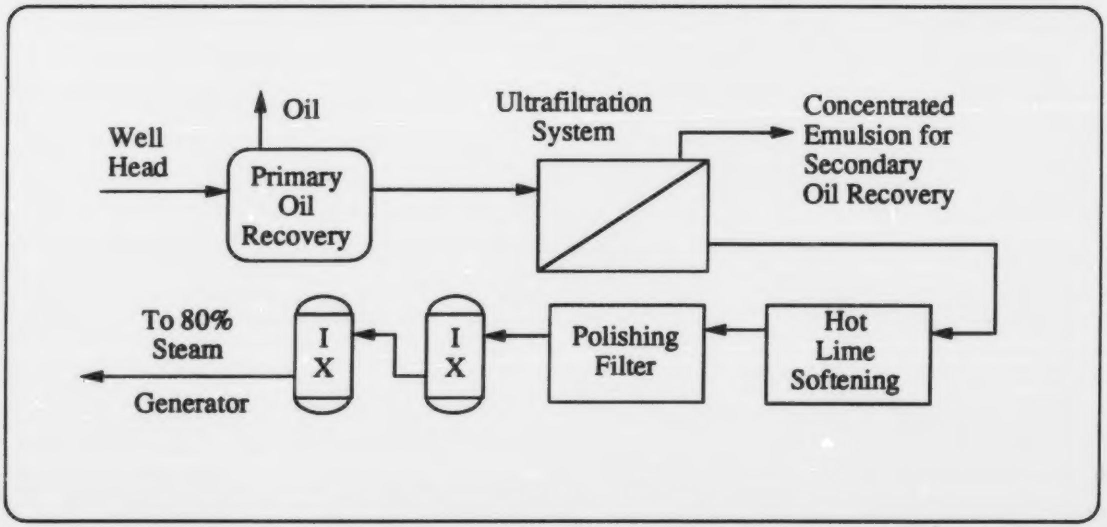

Oil
Oil
Oil
Well Head
Primary Oil Recovery
Skim Tank
Induced Gas Floatation
Sand Filter
Demulsifier
To 80% Steam Generator
I X
I X
Polishing Filter
Hot Lime Softening

FIGURE 1-2

Potential Membrane Treatment Process


Oil
Well Head
Primary Oil Recovery
Ultrafiltration System
Concentrated Emulsion for Secondary Oil Recovery
To 80% Steam Generator
I X
I X
Polishing Filter
Hot Lime Softening

Ultrafiltration offers a potential alternative to conventional treatment technology. The ideal produced water treatment process would have a simplified flow scheme and would require little or no chemical addition. Ultrafiltration meets this criteria. Ultrafiltration eliminates the need for both an IGF and sand filter. It can accept high oil concentrations and provide an absolute barrier to emulsified oil. In general, UF treated effluent would contain less oil than conventional treatment, the system would not be prone to "breakthrough", and would remain relatively stable during process upset conditions. On this basis, UF would appear superior to conventional technology. Figure 1-2 illustrates the ultrafiltration alternative produced water treatment solution.

Previous ZENON studies[1] have examined the potential for UF membrane systems to treat produced water. Different samples of produced water were tested from different EOR sites within Western Canada. The results of these studies demonstrated good potential for applying cross-flow tubular ultrafiltration for the removal of oil from EOR produced water. The performance of the membrane system was highly site specific and appeared to be more influenced by the stability of the emulsified oil rather than the absolute amount of oil present. Samples from 3 of 9 sites tested resulted in high, stable ultrafiltration flux rates above 167 LMH (4 m^3/m^2/day) and showed no signs of membrane fouling. Other samples resulted in ultrafiltration flux rates as low as 42 LMH (1 m^3/m^2 /day) and showed signs of membrane fouling. The causes for the differences in operating results were not clearly determined, but they were speculated to be largely related to the oil characteristics of the specific geological formation. Methods of improving overall system performance at sites where low flux rates were obtained were investigated and considerable flux improvements were obtained. The encouraging results of this work led to the recommendation for on-site produced water ultrafiltration field experiments to assess ultrafiltration on fresh produced water.

1.2 Objectives

The primary objectives of the on-site UF experiments reported here, are given below:

- to design and build a membrane testing apparatus suitable for on-site UF testing at an EOR operation.
- to determine optimum operating conditions for the produced water UF process application.
- to confirm previous economic assessments of the produced water UF application.

2.0 EXPERIMENTAL PLAN

2.1 Field Test Sites

The goal of the experimental programme was to experiment with ultrafiltration of produced water from different EOR in-situ operations in Western Canada. Two EOR in-situ plants were chosen for the testing, they are referred to Site "A" and Site "B." The existing oil recovery and treatment operations at Site "A" and Site "B" are depicted in Figure 2-1 and Figure 2-2, respectively. Two different feed sources were used during Site "A" tests, whereas only one feed source was used at Site "B." The location of the feed sources used in the different stages of work are also shown in Figure 2-1 and Figure 2-2.

2.2 Membranes

Three different tubular membrane types were used in the experimental testing, they are referred to as HEM, HST, and HSC. All three are suitable for processing an emulsified oil feed stream, but each is uniquely different. Table 2.1 provides a comparison of the membrane types used in testing.

TABLE 2-1
Membrane Characterisation Data

Membrane	Surface	MWCO	Oleophobicity	Hydrophilicity
HEM	anionic	5000	level - 1	level - 2
HST	anionic	5000	level - 2	level - 1
HSC	anionic	10000	level - 2	level - 1

MWCO = Molecular Weight Cut Off

Here, level-1 and level-2 define, in relative terms, the degree of oleophobicity and hydrophilicity; where level-1 is a higher degree than level-2. Because of the higher hydrophilicity of

Figure 2-1
Process Flow Schematic of Site "A" Enhanced Oil Recovery Operation

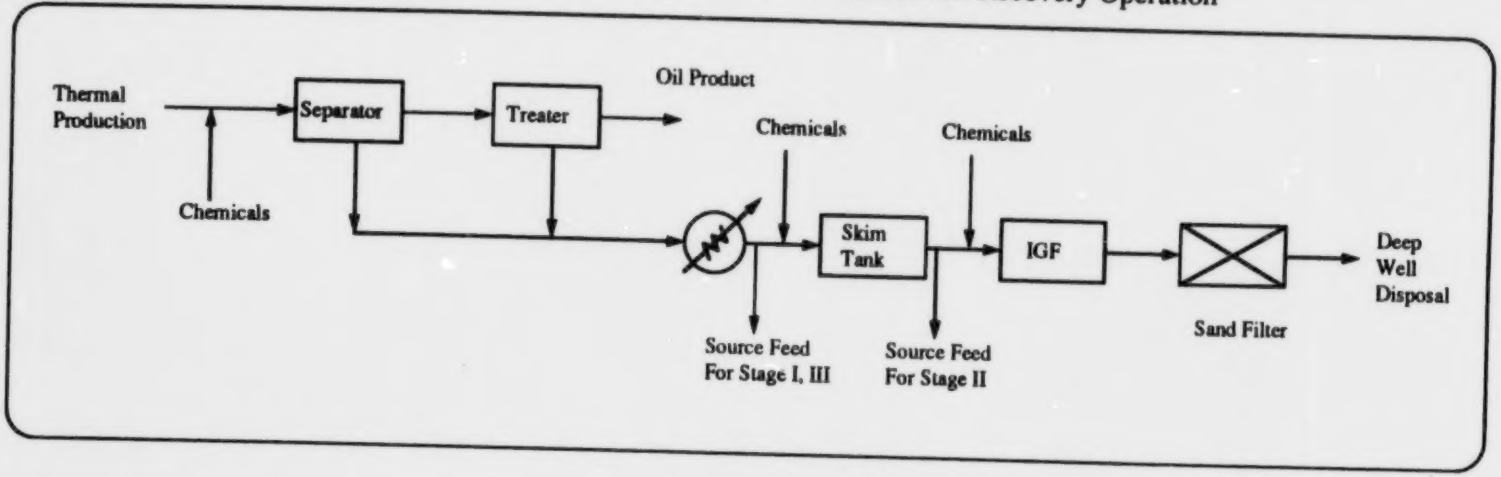
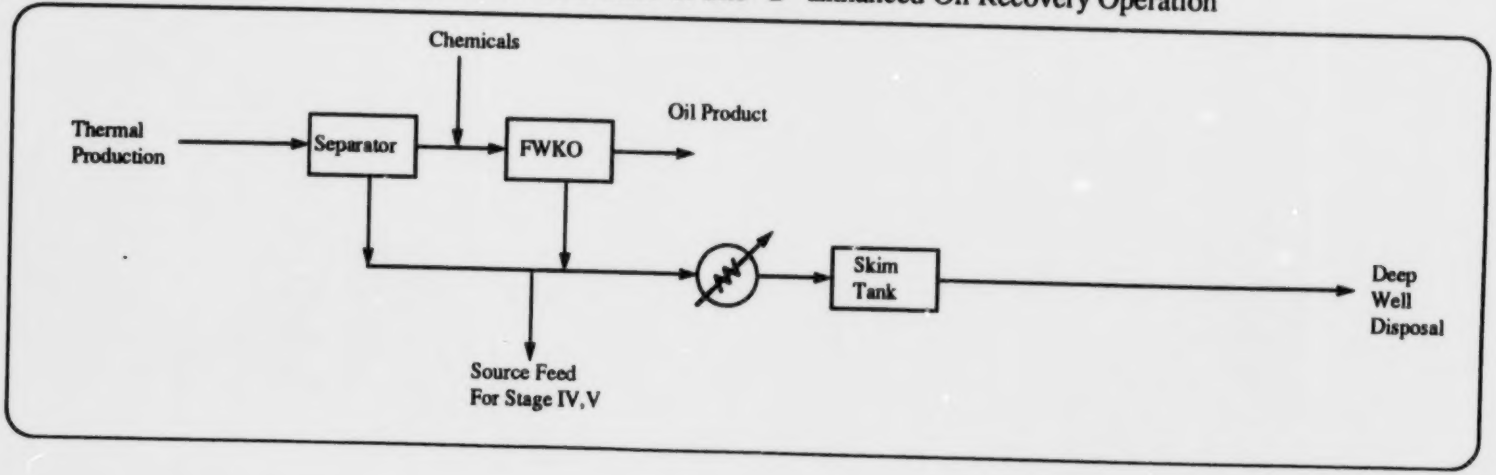

Thermal Production
Chemicals
Separator
Treater
Oil Product
Chemicals
Chemicals
Skim Tank
IGF
Sand Filter
Deep Well Disposal
Source Feed For Stage I, III
Source Feed For Stage II

Figure 2-2
Process Flow Schematic of Site "B" Enhanced Oil Recovery Operation


Thermal Production
Chemicals
Separator
FWKO
Oil Product
Skim Tank
Deep Well Disposal
Source Feed For Stage IV,V

the HST and HSC, these membranes would be expected to out perform the HEM in the absence of free oil foulants in the feed stream. However, the more oleophobic HEM is expected to foul less and respond more effectively to cleaning than the other two when free oil is present. The testing of all three of types provided a good cross-section of membranes for evaluating the produced water UF application.

The membranes tested have two points of reference: membrane type and identification number. Membrane type specifies HEM, HST, or HSC membrane, and the identification number specifies the particular membrane tested out of a possible series within a membrane type. Each membrane type has the same polymer chemistry and molecular weight cut off (MWCO) regardless of the identification number.

Membrane modules were used to house the individual membrane tubes. Two different module configurations were considered for experimental testing: a "7-tube" module and an "8-tube" module. Both types of modules were designed with replaceable membrane tube inserts to improve the efficiency and cost of replacing membrane tubes in the field. In addition, both modules were composed of CPVC housings and fibre reinforced plastic support tubes. The "8 - tube" module is composed of 8 tubes (2.22 cm, 7/8 in ID) connected in series and the "7 - tube" module is composed of 7 tubes (1.27 cm, 1/2 in ID) connected in parallel. In all cases, the membrane tubes installed in a single module were of the same type. Each was given an identification number (e.g. HEM-01). The "7-tube" module has the advantage of lower pressure losses but the disadvantage of requiring higher pumping capacities, whereas the "8-tube" module has the advantage of lower pumping capacities but the disadvantage of higher pressure losses. Unfortunately, the "7-tube" module failed in early in-house testing due to a compatibility problem between the membrane and membrane support. The compatibility problem was not solved during the test programme and, as a result, the "8-tube" module was used exclusively in testing. The "7-tube" module is commercially available for lower temperature operation (<50°C), but more development is needed for success at produced water temperatures (~75°C).

2.3 Pilot Test Equipment

2.3.1 Design Objectives

The UF pilot test equipment was built especially for the produced water field test study. The design of the test system is much the same as the standard ZENON ultrafiltration system, but with a number of enhancements to meet the special requirements of the particular process application. These requirements are presented and discussed below:

- High temperature operation
- Corrosion resistance
- Variable operating modes
- Pretreatment of free oil
- Sealed and Explosion proof

In order to operate at high temperatures, each system component was specified to meet or exceed the target operating temperature of 75°C. The process tank was designed with both a steam heating system and a cooling water system with automatic activators to ensure that the process would operate at the required temperature. In addition, the system (i.e. tanks and piping) was insulated with aluminium wrapped fibreglass to ensure minimum heat loss and maximum worker protection. The membrane modules were constructed of chlorinated polyvinyl chloride (CPVC). The plumbing on the inlet and outlet of the modules were gasketted flange to flange connections to allow for sufficient expansion and contraction of mated CPVC and 316ss materials.

All plumbing components were specified as 316ss or CPVC material and a ceramic mechanical seal was specified for the centrifugal pump. This specification gave the equipment resistance to damage from produced waters containing high concentrations of salt.

Operating mode flexibility was gained through the installation of programmable logic controller (PLC). Three level switchs in the main process tank fed information to the PLC to act appropriately for the specified mode of operation. The three common modes used in the testing were regular batch mode (RBM), modified batch mode (MBM), and feed and bleed mode (FBM). Details on the three operating modes are in Appendix G.

Free oil was removed from the feed stream using a gravity separator. A continuous produced water feed stream was supplied to a 946L, 316ss, gravity separation tank having three out-flows: an overflow for removal of free oil floating on top of the aqueous phase (waste), and mid-level draw off for removal of aqueous phase (feed), and an under-drain for removal of settled solids (waste).

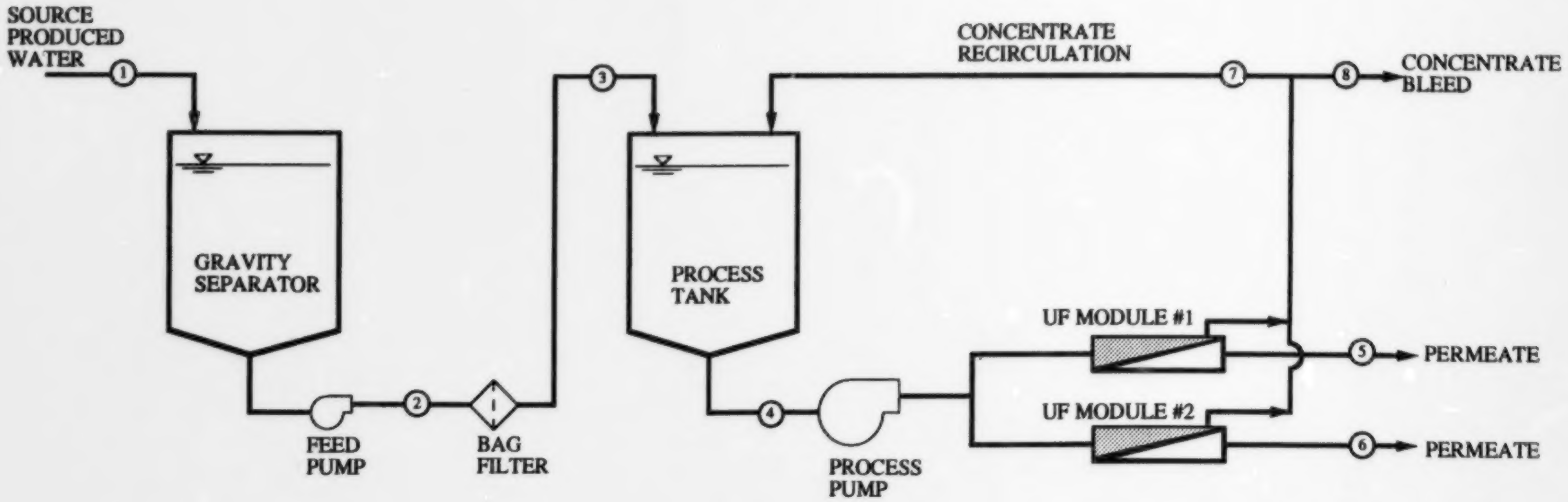
The potential for explosive and/or toxic gases to be present on site made it necessary for the system to be both explosion proof and completely sealed. All external electrical switches, motors, conduit and the electrical enclosure were CSA approved for Class 1 Division 1 Group D explosion proof rating. All tanks were sealed with gasketted 316ss lids bolted in place. All sample ports were designed with bull plugs to ensure no process fluid leakage.

2.3.2 Process Description

The ultrafiltration process equipment was fundamentally the same at both site "A" and site "B," with the exception of auxiliary equipment (e.g. pretreatment, cleaning system). Gradual improvements were made to the auxiliary equipment and its operation as more was learned about the UF application. Specific information about improvements are covered in Sections 3.2 and 4.2.

Produced water feed was accepted at the gravity separation feed tank, where the feed was coarsely separated into three phases: free oil, aqueous, and solids. Free oil continuously overflowed the top of the separator, solids were periodically removed from the bottom of the separator and an aqueous phase was drawn from a mid-point in the separation tank and pumped to the process tank for further treatment. This pump transfer of aqueous phase to the process tank was on a demand basis according to level switch activation on the process tank. Three level switches were located inside the process tank, the top two controlled the on/off to the transfer pump to maintain a full process tank, and the bottom level switch was for system shut-off to end RBM operation or to protect the system in the case of interrupted feed. Produced water was drawn from the bottom of the process tank and pumped to two membrane modules connected in parallel. The specific flow and pressure to the modules were controlled using valving on the upstream and downstream sides of the module. The membrane modules separate the feed stream into a concentrate and permeate stream. The concentrate flow was measured with in-line flowmeters and the applied pressures were measured with gauges on the feed and concentrate sides of the membrane. The concentrate was directed back to the process tank and/or discharged from the system, depending on the mode of operation. The permeate flow from each of the modules was measured independently with a flowmeter and then discharged from the system. At both Site "A" and Site "B" the concentrate and permeate discharged from the UF system were recombined and directed back into the produced water treatment operation (i.e. no recovery or reuse of products was undertaken). The simple process flow diagram for the UF system is depicted in Figure 2-3, and a more detailed process and instrumentation diagram is shown in Appendix G.

FIGURE 2-3
Produced Water Ultrafiltration Pilot Test System


SOURCE PRODUCED WATER
1
GRAVITY SEPARATOR
FEED PUMP
2
BAG FILTER
3
PROCESS TANK
4
PROCESS PUMP
CONCENTRATE RECIRCULATION
7
8
CONCENTRATE BLEED
UF MODULE #1
UF MODULE #2
5
PERMEATE
6
PERMEATE

Stream Identifier	Sample Description
1	Source Feed
2	Prefilter Feed
3	Process Feed
4	Membrane Feed
5	Module #1 Permeate
6	Module #2 Permeate
7	Concentrate Recirculation
8	Concentrate Bleed

The system was equipped with several protective devices to ensure the safety of the system and the operator. These devices include: a high/low pressure switch on the process pump discharge to protect the system from over pressurization (high) and pump starvation (low), a high temperature switch on the feed line to protect the system against temperatures above 75°C, and circuit breakers to protect the system from electrical overload. All of these protective devices helped to avoid damage by shutting down the system immediately.

The operating conditions were kept as constant as possible throughout the testing at Site "A" and Site "B." The constant conditions gave the benefit of comparing different membranes from different stages of testing. Conditions where selected based on prior experience with the produced water ultrafiltration application, and the need to provide the best potential for long term flux. The operating conditions were kept as close as possible to those shown in Table 2-2.

TABLE 2-2
Approximate Ultrafiltration Operating Conditions for Each Module Position

PARAMETER	SETTING
Inlet Pressure (kPa)	415
Outlet Pressure (kPa)	105
Feed Flow Rate (L/min)	105*
Feed Temperature (°C)	73

*** The feed flow rate measured and reported in Appendix B and Appendix D is inaccurate on many occasions due to faulty flow measuring equipment. An accurate estimate was determined empirically from pressure drop information, and a flow of 105 L/min can be assumed for a ΔP of 310 kPa @ 73°C through a ZENON 8 tube membrane module.**

2.4 Membrane Cleaning

Periodic membrane cleaning was often needed to restore fouled membranes used in the ultrafiltration process. Chemical cleaning was used most often, and required taking the UF system off process feed and recirculating MC-3 through the membrane modules. MC-3 is a ZENON product based on an industrial strength surfactant and specifically designed to remove produced water oil foulants. The cleaning procedure guideline used in this study was to: 1) shut the UF system down, 2) purge the process tank with softened water (i.e. boiler feed water), 3) mix the MC-3 in a solution of approximately 200 L of water at a temperature of approximately 70°C, 4) recirculate the solution for approximately one hour, 5) purge the system with softened water and 6) restart system on process feed. This guideline was often adjusted during testing to improve cleaning effectiveness, the details of which can be found in Sections 3.2 and 4.2.

2.5 Membrane Evaluation

Membrane evaluation was based on measured flux and rejection parameters characterizing membrane performance. The flux parameter is described as:

Flux = volume rate of membrane permeation / available membrane area

Where permeation is measured in L/h and membrane area is measured in m^2 (1 m^2 per "8-tube" module). Therefore, flux is expressed in the units of $L/m^2/h$ or simply written as LMH. Refer to the ABBREVIATIONS section for conversions from LMH to m^3/m^2/day or US gal/ft^2 /day. Membrane rejection parameter is represented as a percentage:

$$\% \text{ Rejection} = (X_f - X_p) / X_f \times 100\%$$

where X is the chemical analysis parameter of interest, and the subscripts "f" and "p" define membrane feed and membrane permeate respectively. Membrane feed is defined as the liquid the membrane is exposed to at the time of permeate sampling and/or flux measurement.

2.6 Sample Analysis

Sampling of streams during experiments was important to the assessment of membrane rejection as well as the nature of the feed stream processed by the membrane . In most cases, samples sets were taken daily to measure Total Oil (TO), Total Dissolved Oil (TDO), Total Suspended Matter (TSM) (often broken down into hydrocarbon and solids), Total Dissolved Solids (TDS), and pH. Less frequent samples were taken for parameters such as Calcium (Ca), Magnesium (Mg), Silicon (Si), Sodium (Na), Chloride (Cl), and hardness. The procedures used for these analyses are presented in Appendix E. Some special analyses were also conducted on the feed samples from both sites to characterize for Zeta potential and particle size distribution. The procedure for these analyses are also in Appendix E.

3.0 SITE "A" RESULTS AND DISCUSSION

3.1 Feed Characterisation

Skim Tank influent was the source feed for Site "A" tests, and it was characterised for particle size distribution and Zeta potential . The average particle size was 2.1 μm; with an standard deviation of 1.3, and the Zeta potential was -35.6 mev; with a standard deviation of 1.3. Refer to Appendix F for analytical methods.

In addition, the stability of the source feed was tested for effects of pH, age, and heat. No significant changes in the sample were seen as the pH was increased above control (pH 8.05), however, coalescence and settling did occur in the acidic range. The sample turned dark with age, and heating of the sample caused some free oil to coalesce and form on the solution surface, corresponding to effects noted in earlier work[1]. Refer to Appendix F for experimental data.

3.2 Experimental

Site "A" tests are divided into three stages and are represented in Table 3-1

TABLE 3-1
Description of Test Stages at Site "A"

Stage	Period	Runs	Source Feed	Mode
I	18-Aug-88 to 12-Sep-88	1 to 11	Skim Tank Influent	RBM
I	30-Sep-88 to 14-Oct-88	20 to 24	Skim Tank Influent	RBM
II	15-Sep-88 to 28-Sep-88	12 to 19	IGF Influent	RBM
III	26-Oct-88 to 31-Oct-88	25 to 28	Skim Tank Influent	MBM

Two different feed streams were experimented with at Site "A": produced water tapped from the Skim Tank influent (upstream of chemical addition) during Stage I and, produced water tapped from the IGF influent (downstream of chemical addition) during Stage II, see Figure 2-1. The Skim Tank influent was used again during Stage III but it was first pretreated with particle filtration. Small black particles could be seen suspended in Skim Tank influent feed to the membranes. These particles did not have a preference to float or sink in the gravity separation feed tank and, as a result, were not adequately removed from the feed stream. The particles were suspected to be oil related, and since membranes are known to foul in the presence of free oil, it was important to remove these particles from the membrane feed. A 20 μm bag filter was installed to retain the suspended particles and to allow the emulsified oil to pass through.

Most of the tests at Site "A" were conducted in regular batch mode (RBM) and took anywhere from 2 to 5 hours to complete, depending on the type of membrane being used, its condition (clean or fouled), and the source feed. All of the RBM runs reported reached an approximate 90% volume reduction with a final concentrate volume of 57 L. A sample of the membrane feed was taken at the beginning and the end of the batch run and a permeate sample only at the end. Late in the testing at Site "A," some of the tests were conducted in MBM. These runs took approximately 20 hours to reach a 90% volume reduction with a final concentrate volume of 560 L. A sample of the membrane feed was taken at the beginning of the run and then at six hour intervals in addition to permeate samples.

The UF system operating conditions for Site "A" are outlined in Section 2.3.2 and can be reviewed in detail in Appendix A.

The TO and TDO of samples where analysed by two different laboratories during Site "A" tests, the laboratories are referred to in Appendix B as Lab #1 and Lab #2. The same analytical procedures were used by both laboratories yet there was often large differences between the two results. The differences reflect the inherent inaccuracy in this type of analytical measurement, and the need for both an improved and standard method for heavy/bitumen oil TO measurement. Despite the differences, an average TO and average TDO are expressed in Section 3.0 based on the results from each laboratory.

All of the cleanings at Site "A" involved MC-3. The cleanings were scheduled at the end of each batch run and involved taking the system off-line to circulate the cleaning fluids from the process tank. The dosage of MC-3 was increased by four times (4XMC-3) for cleanings at Run 12 and beyond. The period for cleaning was experimented with throughout Site "A" tests, and may vary from one hour to an overnight soak. The exact details of the cleaning periods and dosages are documented in Appendix A. Results of cleaning approaches used at Site "A" are discussed in Section 3.3.

High concentrations of hydrogen sulphide (H_2S) associated with the produced water were a safety concern at Site "A" and, as a result, precautionary measures, such as sealed and vented tanks on the UF system and self contained breathing apparatus when sampling, were required to maintain safety. In addition, H_2S training was required for all operators of the UF system.

3.3 Results

The results from Stage I, Stage II, and Stage III are discussed independently and summarized at the end of this section. A focus is placed on the results of membrane flux and membrane rejection characteristics. Operating results are taken from data in Appendix A and presented in graphs of flux versus run time. Numbers along the flux versus time plot line indicate the reference number for the run and, in most cases, the time of membrane cleaning (exact cleaning times should be taken from

Appendix A). Membrane rejection of TO is taken from Appendix B and is presented in Tables 3-2, 3-3 and 3-4. Rejection of other parameters, such as TDO, TSM, TDS, and ions, are also reported in Appendix B but not presented in the text. All of the membranes tested reject virtually all TSM and no TDO, TDS or ions. This performance is expected given the level of MWCO of each of the membranes tested (see Table 2-1).

3.3.1 Stage I

Conditions

The membrane feed changed as illustrated in Figure 3-1 for the 58 run hours of Stage I. The concentration of TO and TSM appear closely related in Stage I, as both parameters under went similar change, especially at the 40 hour mark. This relationship is not surprising when we note the hydrocarbon (oil) component in the TSM is often roughly the same order of magnitude as the TO concentration. This finding indicates TO is largely made up of oil coated particles. The TDO, on the other hand, appears independent of either TO or TSM, as it remained relatively constant through their changes.

Membrane Performance

Three membranes were tested during Stage I; the HEM-01, the HST-01, HST-03 and the HSC-01. In general, all three membranes rejected all visible suspended oil and suspended solids, and rejected little of dissolved oil and dissolved solids.

A summary of TO rejection and average flux performance for each membrane tested is shown in Table 3-2. A graph of feed and permeate TO versus run time for each membrane is shown in Figure 3-2. In addition, a graph of flux versus run time results for the HEM series is shown in

FIGURE 3-1

Site "A," Stage I, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO), and Total Suspended Matter (TSM) Versus Run Time.

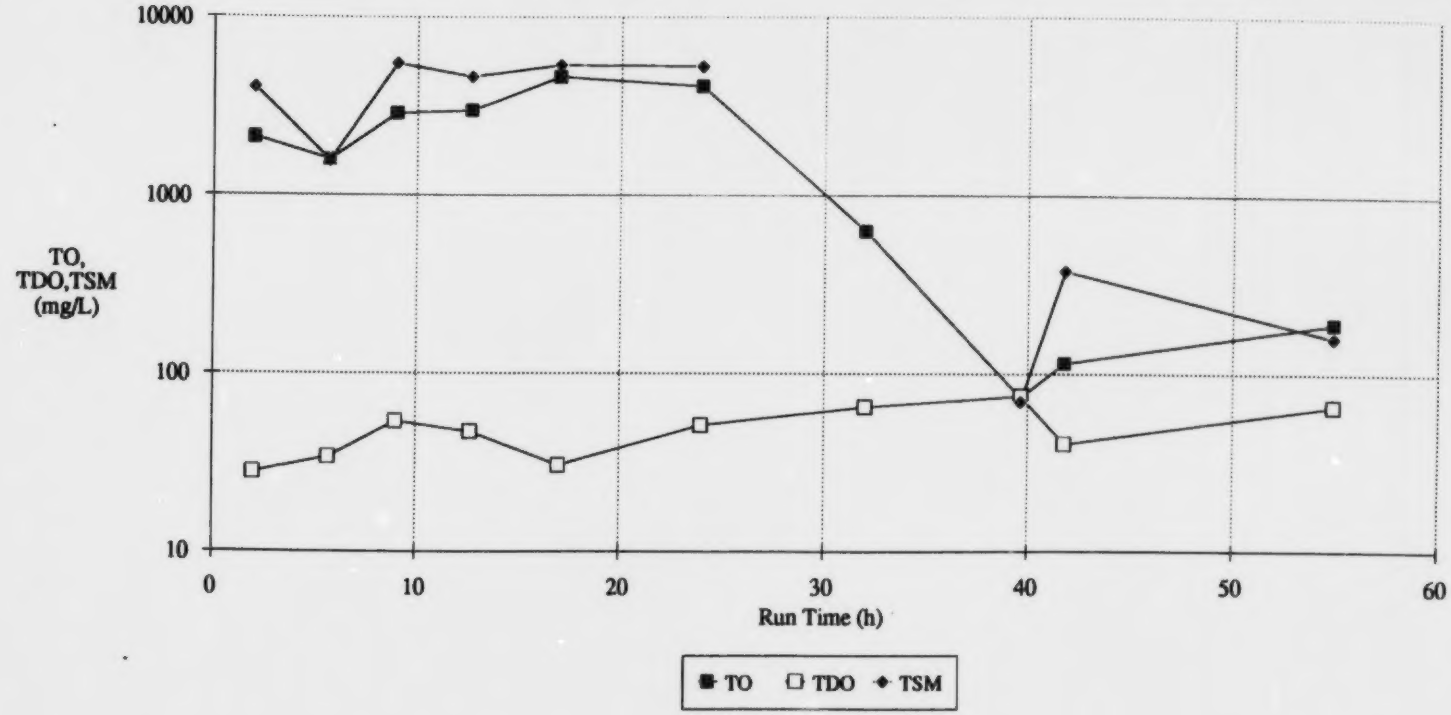


FIGURE 3-2

Site "A," Stage I, Membrane Feed Concentration of Total Oil and HEM-01, HST-01, HST-03, and HSC-01 Permeate Concentration of Total Oil Versus Run Time.

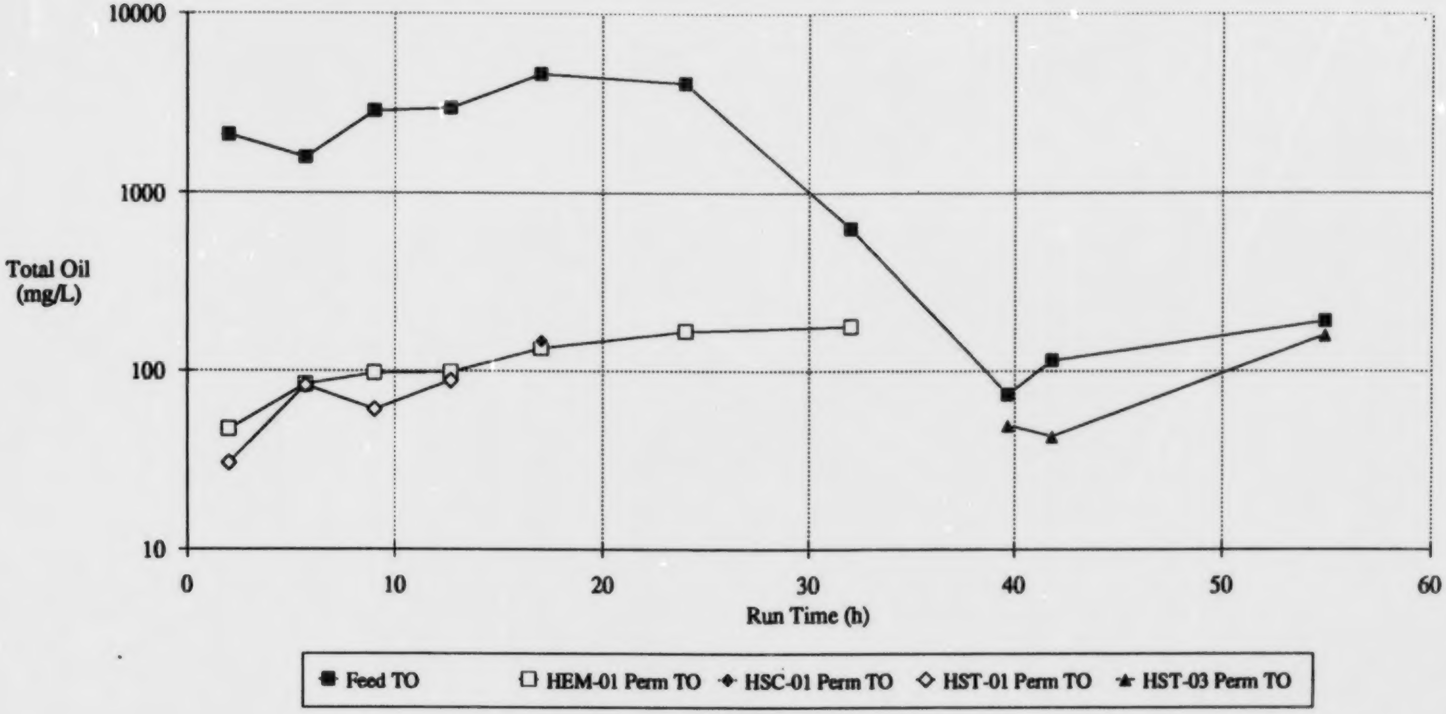


Figure 3-3 and the same results for the HST and HSC are shown in Figure 3-4. Details of membrane performances from Stage I are considered below.

TABLE 3-2
Site "A," Stage I, Average Flux and Rejection Summary

Membrane Type	Total Run Time (h)	Average Flux (LMH)	sd	Average TO in Feed (mg/L)	sd	Average TO in Perm. (mg/L)	sd	Average % TO Rejection	sd
HEM-01	34	110	56	2713	1298	115	43	93	9
HST-01	19	107	73	2396	576	66	23	97	1
HST-03	20	132	99	127	49	84	46	37	16
HSC-01	7	146	92	4663	na	148	na	97	na

Notes: sd = standard deviation
na = not available

HEM-01:

The average TO permeate quality from the HEM-01 was 115 mg/L, corresponding to an average rejection of 93% of the TO fed to the membrane. From Figure 3-2, the HEM-01 permeate TO concentration appears to gradually increase throughout Stage I tests.

The average flux for the HEM-01 was 110 LMH over 34 hours of run time. The HEM-01 flux decreases quickly initially and then showed signs of stability in Figure 3-3. The first 16 hours of operation appear to be a "conditioning" stage for the HEM-01, where the flux started at 330 LMH and declined to 70 LMH at the end of Run 5. A "conditioning" stage is common for any new membrane and it is speculated the surface chemistry and membrane morphology are adjusting (through irreversible fouling) to the feed stream. Cleaning with MC-3 during this stage did not appear to make a significant improvement in flux, however a large flux gain was noted after Run 5

FIGURE 3-3
Site "A," Stage I, Flux Versus Run Time for the HEM-01 Membrane.

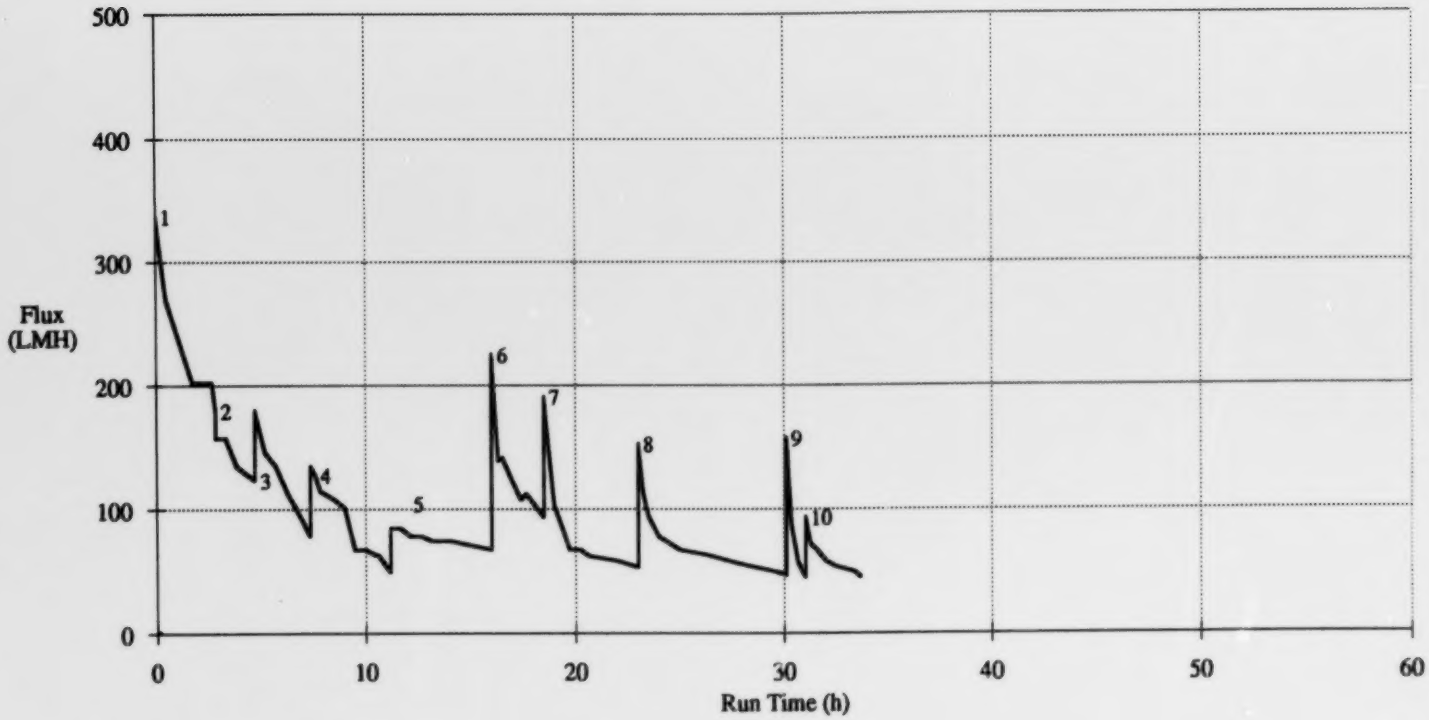
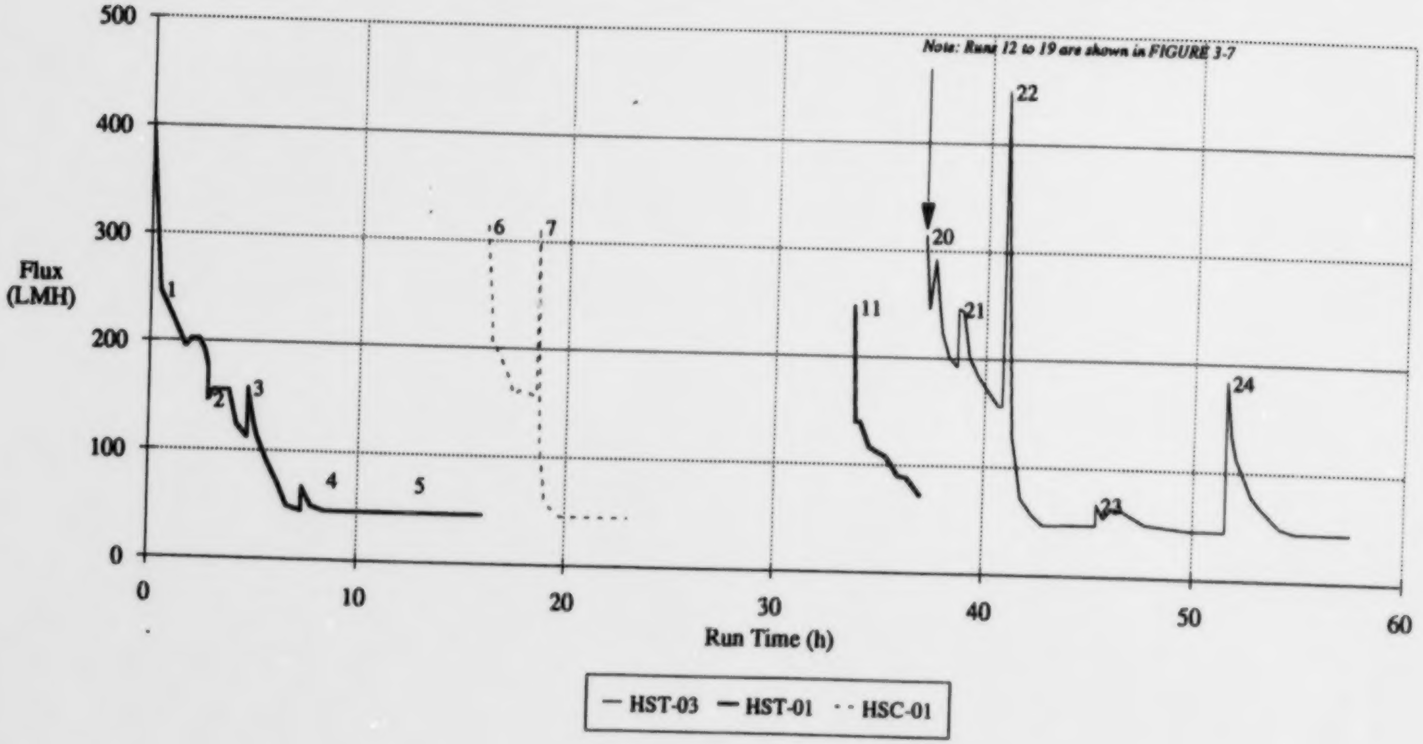


FIGURE 3-4
Site "A," Stage I, Flux Versus Run Time for the HST-01, HST-03, and HSC-01 Membranes.



when an overnight soaking in MC-3 was tried. However, overnight soak cleanings, following Runs 6, 7, 8, and 9, showed no signs of restoring the HEM-01 flux, suggesting the cleaner is not aggressive enough to remove the foulants no matter how long the contact time. The cleaning effects slowly diminished after each run and the HEM-01 was taken off-line at the end of Run 10 at a flux of approximately 70 LMH.

HST-01:

The average TO permeate quality from the HST-01 was 66 mg/L, corresponding to an average rejection of 97% of the TO fed to the membrane. From Figure 3-4, the HST-01 permeate TO concentration increased gradually according to an increase in feed TO.

The average flux for the HST-01 was 107 LMH over 20 hours of run time. The HST-01 flux followed a similar trend to the HEM-01 during the first two runs, but then showed little response to cleaning after Run 2. The HST-01 was taken of line at the end of Run 5, at a flux of <50 LMH, and was sent back to ZENON (Burlington) for cleaning studies. Although the HST-01 appeared to foul at the same rate as the HEM-01, it did not respond as well to cleaning. This response was expected, based on the membrane characteristic differences outlined in Table 2-1, since the HEM is more oleophobic than the HST and would therefore clean more easily if fouled with oil.

The ZENON cleaning studies were successful at rejuvenating the HST-01. The HST-01 membrane was cleaned at ZENON with four times strength MC-3 cleaner and 2% (by Vol.) isopropyl alcohol. The more aggressive cleaner rejuvenated the pure water flux of the membrane and indicated no signs of damage to the membrane. The HST-01 was returned to Site "A" and installed on the UF system for Run 11. From Figure 3-4, the HST-01 indicated significant flux gains from the special cleaning; increasing from <50 LMH after Run 5 to 250 LMH at the beginning of Run 11.

However, the flux declined sharply over Run 11, demonstrating a persistent foulant was causing the flux decline. The HST-01 was taken off-line after Run 11 so other membranes could be tested.

HST-03:

The average TO permeate quality from the HST-01 was 84 mg/L, corresponding to an average rejection of 37% of the TO fed to the membrane. From Figure 3-4, the HST-03 permeate TO concentration is quite comparable to the other membranes, even though the percent rejection of TO is low due to the dramatic drop in TO during this run period.

The average flux for the HST-03 was 132 LMH over 3 hours of run time late in the testing at Site "A". For Runs 20 and 21, the membrane performed slightly better than the HST-01 and cleaned remarkably well with a 4XMC-3, plus 2% IPA cleaning following Run 21. The HST-03 flux decreased sharply during Run 22 and showed little sign of flux recovery following a repeat cleaning at the end of Run 22. Surprisingly, a better flux recovery was noted following an additional repeat cleaning after Run 23 - possibly an additive effect of several consecutive cleanings. The module seals holding the HST-03 membrane failed near the end of Run 24, resulting in damage to the HST membrane and its removal from the UF system. The seal damage caused leakage of feed to the permeate side and therefore possibly explains the swings in flux from the HST-03.

HSC-01:

The TO permeate concentration from the HSC-01 was 148 mg/L, corresponding to a percent rejection of 97% of the TO fed to the membrane. Note, the HSC-01 was only on the system for a short time and only one sampling was used for the TO calculations in Table 3-2.

The average flux for the HSC-03 was 146 LMH over 7 hours of run time. The HSC started with a flux of approximately 300 LMH and then declined to 160 LMH. A standard cleaning following Run 6 returned the flux to approximately 300 LMH, but the flux decreased dramatically during Run 7. The cause of the flux decline is unknown, however a change in feed is speculated as the cause since an accidental demulsifier overdose was known to have occurred upstream the day before Run 7. The demulsifier was cationic in charge and would be naturally attracted to the anionic membrane surface. The binding of the demulsifier to the surface would most likely interfere with flux performance. The HSC-01 did not respond to the MC-3 soak cleaning following Run 7 and was sent back to ZENON for analysis. The HSC-01 was lost in shipping to ZENON and was never recovered for analysis.

Stage I Discussion

All three membrane types gave surprisingly similar rejections for all component concentrations. Further review of the analytical results in Appendix B indicate all three membrane types rejected approximately: 97% of TO, 0% of TDO, 98% of TSM, and 0% of TDS. These results indicate the MWCO and chemistry of each membrane is not distinct enough to cause a significant change in rejection performance. The quality of permeate is excellent, as it meets the conventional treatment requirements of removing virtually all suspended solids and suspended oil.

All of the membranes tested showed signs of fouling and flux reduction with run time. Since different membrane types were tested at different run times, it is difficult to compare the flux results from each. The HEM-01 is likely the most representative of the membranes as it ran for the longest period of time. Although the average flux for the HEM-01 was 110 LMH, the standard deviation was 56, indicating much variability in flux over time. Membrane cleanings created most of the flux variability, although this variability was gradually dampened as cleanings became less effective over time. Even though the higher strength 4XMC-3 cleaner appeared to be a more effective cleaner than the MC-3 cleaner, irreversible fouling persisted to reduce membrane flux performance. The irreversible fouling is most likely related to free oil (bitumen) in the feed stream. It is speculated this free oil is in the form of solids suspended in the feed stream, either on its own or attached to other solids. According to the TSM data in Appendix B, as much as 90% of the TSM is made up of hydrocarbon, thus confirming the presence of free oil foulant. Since removing the foulant from the membrane through cleaning is difficult, the more effective way to deal with the foulant may be to remove it from the feed stream entirely either by settling or by filtering before the membrane. These approaches are applied in Stage II and Stage III.

3.3.2 Stage II

Conditions

The membrane feed changed as illustrated in Figure 3-5 for the 10 run hours for Stage II. The concentration of TO and TSM is roughly an order of magnitude lower in Stage II than in Stage I. The difference is most likely a result of upstream Skim Tank processing (see Figure 2-1) where TSM will settle out and the TO will demulsify, float to the top and be removed. The relationship between TO and TSM does not appear to be as strong as noted in Stage I. The TDO is generally higher in Stage II than in Stage I and again appears independent of either TO or TSM. As already noted, the analytical results for TO are often very different when comparing Lab #1 and Lab #2, this difference is particularly evident during Stage II where two orders of magnitude differences are often reported.

Membrane Performance

Two membranes were tested during Stage II; the HEM-02 and the HST-02. In general, the two membranes did not reject TO as completely as seen in Stage I testing, although the permeate TO concentration did not change significantly.

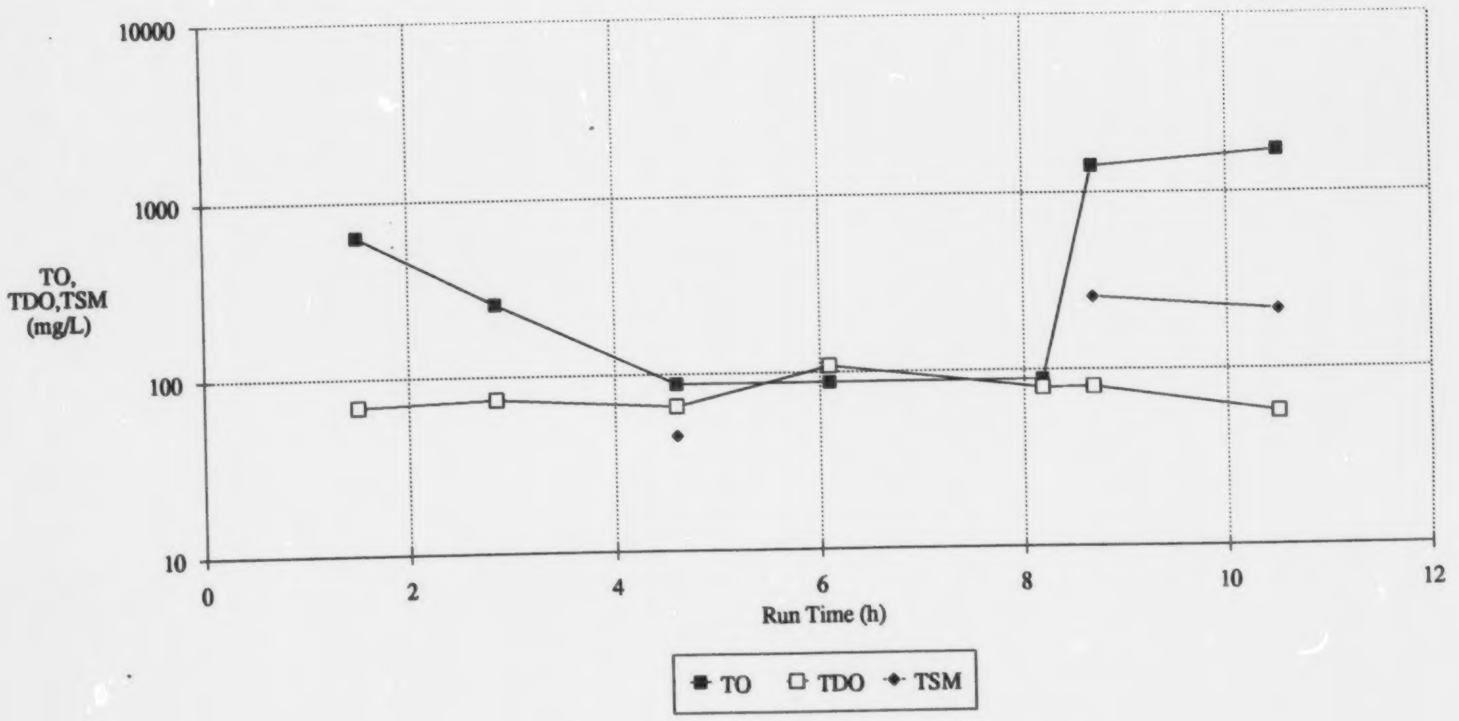


FIGURE 3-5
Site "A," Stage II, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO), and Total Suspended Matter (TSM) Versus Run Time.

A summary of TO rejection and average flux performance for each membrane tested is shown in Table 3-3. A graph of feed and permeate TO versus run time for each membrane is shown in Figure 3-6. In addition, a graph of flux versus run time results for the HEM and HST is shown in Figure 3-7. Details of membrane performances from Stage II are considered below.

TABLE 3-3
Site "A," Stage II, Average Flux and Rejection Summary

Membrane Type	Total Run Time (h)	Average Flux (LMH)	sd	Average TO in Feed (mg/L)	sd	Average TO in Perm. (mg/L)	sd	Average % TO Rejection	sd
HEM-02	11	224	100	611	632	67	33.5	70	32.3
HST-02	8	362	194	677	727	72	19	44	46.1

Notes: sd = standard deviation
na = not available

HEM-02:

The TO permeate concentration from the HEM-02 was 67 mg/L, corresponding to a rejection of 70% of the TO fed to the membrane (see Figure 3-6) - much lower than the TO rejection measured for the HEM-01 in Stage I.

The average flux for the HEM-02 was 224 LMH over 11 hours of run time. The HEM-02 started Run 12 at a flux of 470 LMH, approximately 40% higher than the HEM-01 starting flux in Stage I, and then gradually declined to stable flux of approximately 260 LMH at the end of Run 16. It was encouraging to see reasonably stable high flux performance for the HEM-02 in absence of cleanings between Runs 14, 15, and 16. The flux then decreased during RUN 17 and then again during RUN 18. The membrane did not respond to chemical cleanings following Runs 18 and 19, and was eventually taken off-line after Run 19 to end its experimentation on IGF influent.

FIGURE 3-6
Site "A," Stage II, Membrane Feed Concentration of Total Oil and HEM-02 and HST-02 Permeate Concentration of Total Oil Versus Run Time.

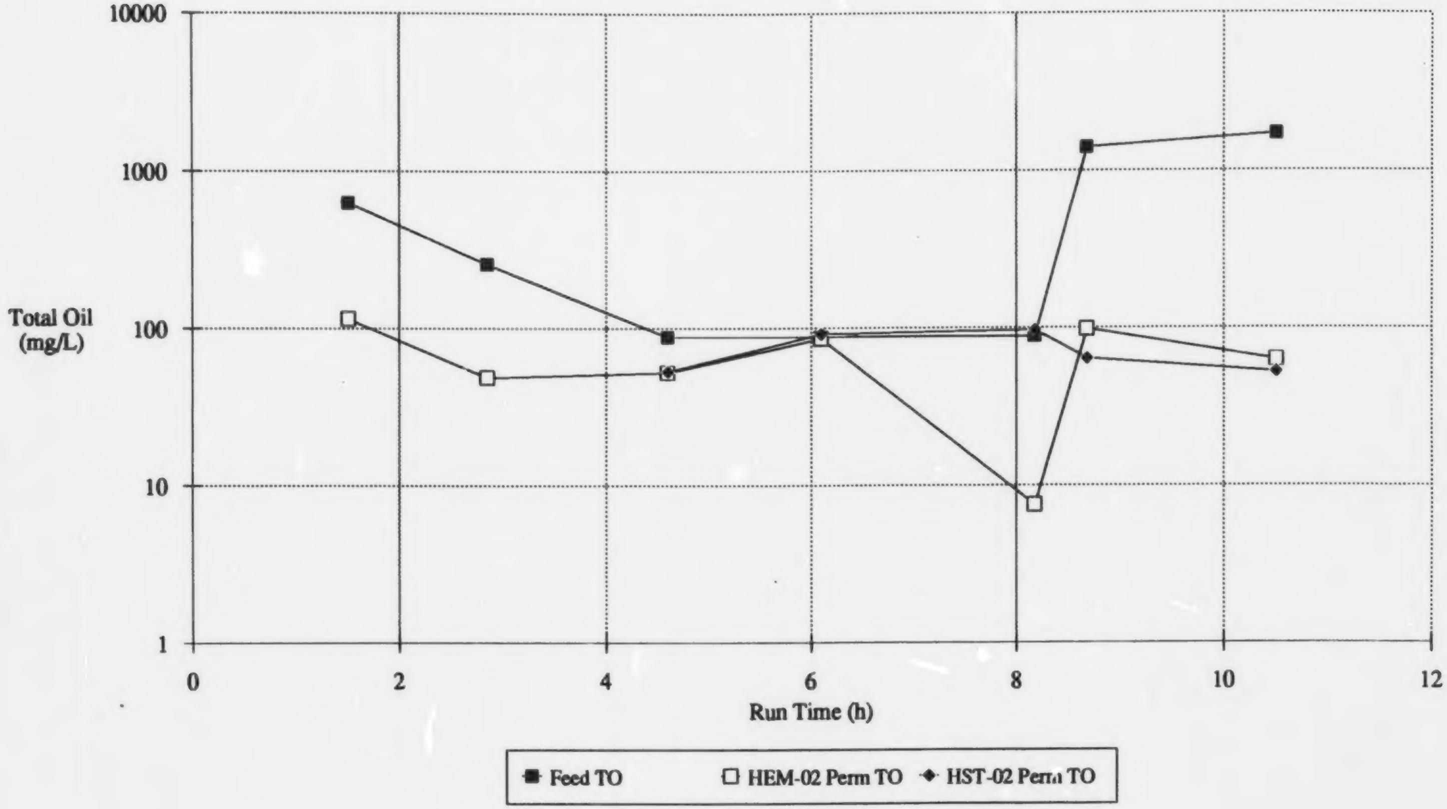
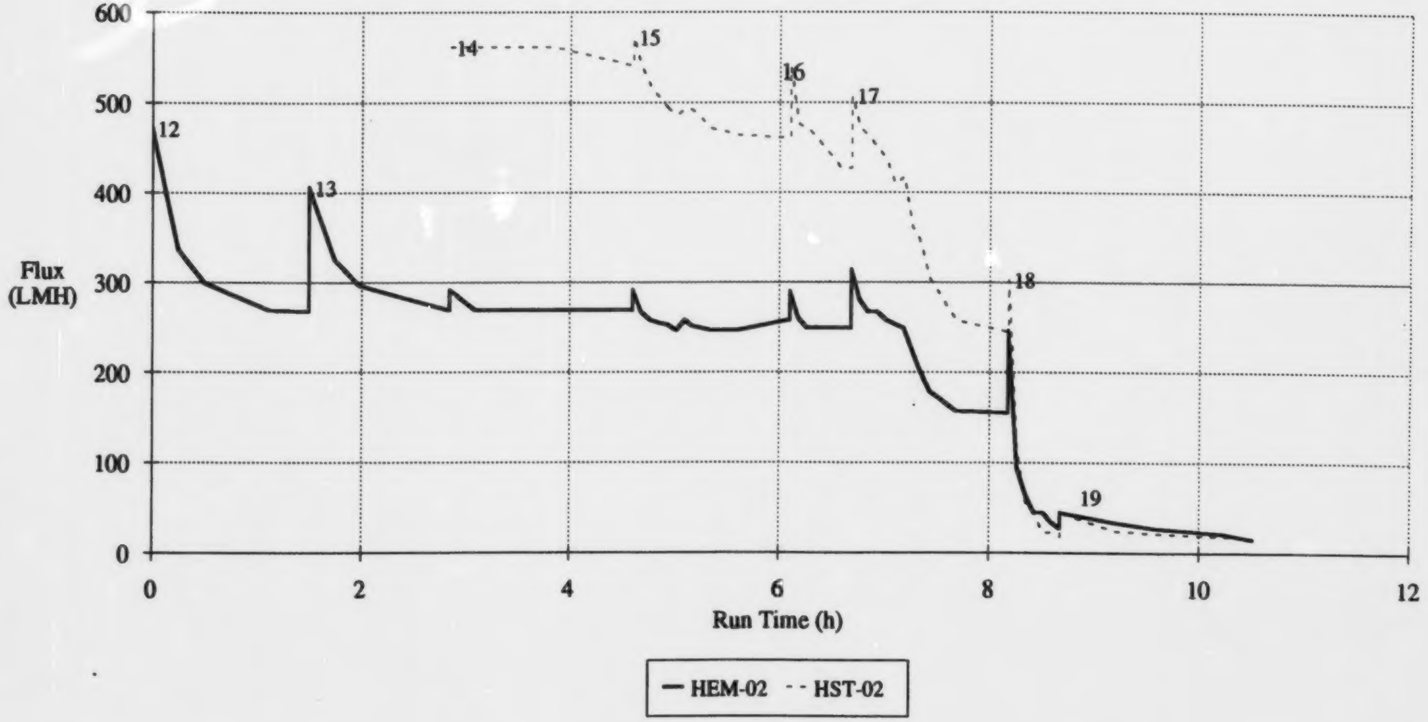


FIGURE 3-7

Site "A," Stage II, Flux Versus Run Time for the HEM-02 and HST-02 Membranes.



Upon inspection of the HEM-02 following Run 19, a "clay like" material was manually scraped from the membrane surface. Analysis of the material indicated an appreciable amount of sulphur. The material had obviously fouled the membrane and was likely the cause of flux reduction. The foulant could be manually removed (rubbing) from the membrane with ease; suggesting a mechanical cleaning, such as sponge balling, may have removed the foulant. Unfortunately, the apparatus to conduct sponge ball cleaning was not available in the field during Site "A" testing. The source of the foulant was never clearly determined, but it has been speculated to be a result of disturbing sediment built up in the bottom of the Skim Tank.

HST-02:

The TO permeate concentration from the HST-02 was 72 mg/L, corresponding to a rejection of 44% of the TO fed to the membrane (see Figure 3-6).

The average flux for the HST-02 was 362 LMH over 8 hours of run time. The HST-02 started Run 14 at a flux of 550 LMH, approximately 40% higher than the HST-01 starting flux in Stage I, and then the flux slowly decreased over Runs 14 through 16 to approximately 450 LMH. The HST-02 flux decreased in similar manner as the HEM-02 during Runs 17 through 19, in addition to indicating the same level of surface fouling of an unknown source.

Stage II Discussion

The oil characteristics of the IGF influent stream were markedly different from those of the Skim Tank influent. The main difference was the lack of TO and TSM in the stream; likely reduced by the up stream Skim Tank operation. The TO removed up stream was mostly emulsified, and therefore the TO in the IGF influent was predominantly soluble (TDO) rather than emulsified oil. Since TDO is expected to pass through the membrane, it is not surprising a low average rejection of

TO was noted during these tests. High rejections (>90%) are note in Runs 18 and 19, and this improvement is attributed to the inexplicable order of magnitude increase in feed TO concentrations during these two runs (refer to Appendix B; Runs 18 and 19).

Surprisingly, the permeate was cloudy in appearance (sometimes as cloudy as the feed) in most of the HEM-02 and HST-02 samples. It is speculated the cloudiness is related to residual demulsifier added to the Skim Tank. The demulsifier is inherently cationic and oleophobic and, if attached to the surface of the membrane, could alter the membrane chemistry toward oleophilicity and ultimately facilitate the passage of oil through the membrane. In addition, it could foul the membrane surface and reduce water flux. Despite the permeate cloudiness, the TO concentration in the permeate was negligibly different from that in Stage I.

Although membrane flux levels were high and stable throughout most of the IGF influent testing, the membrane permeate TO concentration was, at times, no better than the feed - questioning the usefulness of the treatment. Conventional demulsifier oil treatment poses a negative impact on UF, since oil emulsification is desired for UF. The IGF influent (i.e. Skim Tank effluent) holds promise for UF processing however, especially since much of the TSM is removed and mainly emulsified TO remains. If chemicals were removed at the Skim Tank the UF performance would likely improve. More study is needed to understand the effects of demulsifiers on both membranes and produced water before considering the UF processing of IGF influent. The remaining ultrafiltration studies focussed on Skim Tank influent, in order to avoid unnecessary complications in testing.

3.3.3 Stage III

Conditions

The membrane feed changed as illustrated in Figure 3-8 for the 53 run hours of Stage III. Once again, the concentration of TO and TSM are roughly the same. The TDO is similar in concentration to earlier stages and remains relatively constant throughout Stage III.

It is surprising that membrane feed TSM levels are not lower in Stage III than in Stage I, since pretreatment with a 20µm bag filter would be expected to remove most of the TSM. Based on visual inspection, the prefilter effluent was clearer than the prefilter influent, however, the analytical results from the sampling of Runs 25, 26, 27 fail to indicate any significant change in TSM before and after the prefilter (see Appendix B, compare source feed to membrane feed at start up) . Possibly the particles greater than 20 µm in diameter are few in number and where not measured analytically, or maybe nothing was captured at all (further discussed in Section 3.3.4). Inherent analytical variablity may be a cause of error.

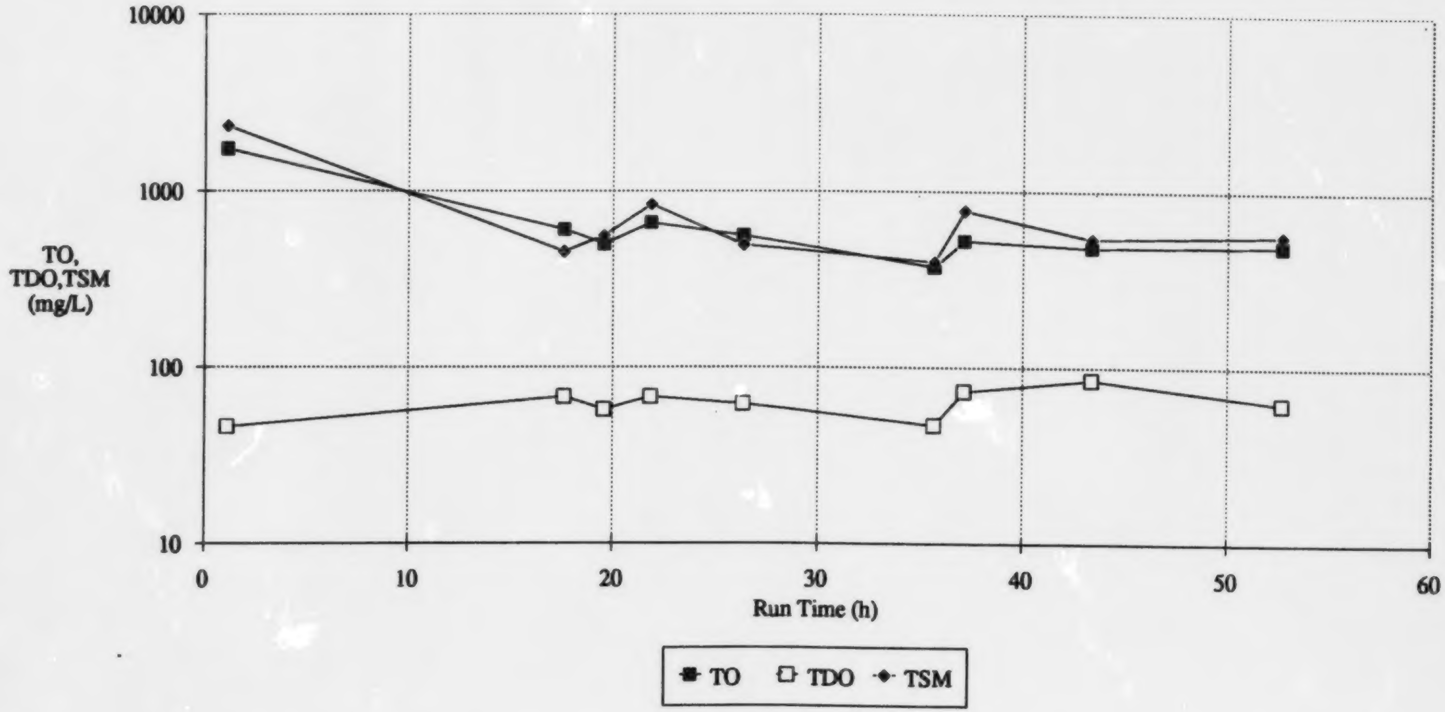
Process Conditions

Stage III operation was different from Stage I and II since the UF system was used in MBM operation. In MBM, the system was run continuously for approximately 20 hours to complete a batch with a final concentrate volume of approximately 570 L. Three batches were run during Stage III and each was monitored continuously throughout the run time. The continuous operation gave the opportunity to evaluate the membranes under more realistic (continuous feed) industrial treatment conditions.

Membrane Performance

Two membranes were tested during Stage III; the HEM-04 and the HEM-06. A summary of

FIGURE 3-8
Site "A," Stage III, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO), and Total Suspended Matter (TSM) Versus Run Time.



TO rejection and average flux performance for each membrane tested is shown in Table 3-4. A graph of feed and permeate TO versus run time for each membrane is shown in Figure 3-9. In addition, a graph of flux versus run time results for the HEM series is shown in Figure 3-10. Detailed membrane performances from Stage III are considered below.

TABLE 3-4
Site "A," Stage III, Average Flux and Rejection Summary

Membrane Type	Total Run Time (h)	Average Flux (LMH)	sd	Average TO in Feed (mg/L)	sd	Average TO in Perm. (mg/L)	sd	Average % TO Rejection	sd
HEM-04	0.4	348	9	na	na	na	na	na	na
HEM-06	59	120	74	657	386	109	20	78	7

Notes: sd = standard deviation
na = not available

HEM-04:

The average flux for the HEM-04 was 348 LMH over 0.4 hours of run time. The HEM-04 started Run 25 at a flux of approximately 260 LMH, but the test ended quickly due to problems with the module. The module seals holding the HEM-04 membrane failed near the end of Run 24 and the membrane became damaged and was removed. More regarding this module problem is described Section 3.4. No feed or permeate samples were taken for chemical analysis.

HEM-06:

The TO permeate concentration from the HEM-06 was 109 mg/L, corresponding to a rejection of 78% of the TO fed to the membrane (see Figure 3-9). The low rejection is somewhat misleading, as permeate quality was as good or better than earlier tests. Lower TO in the feed is the reason for the low average rejection in Stage III.

FIGURE 3-9

Site "A," Stage III, Membrane Feed Concentration of Total Oil (TO) and HEM-06 Permeate Concentration of Total Oil (TO) Versus Run Time.

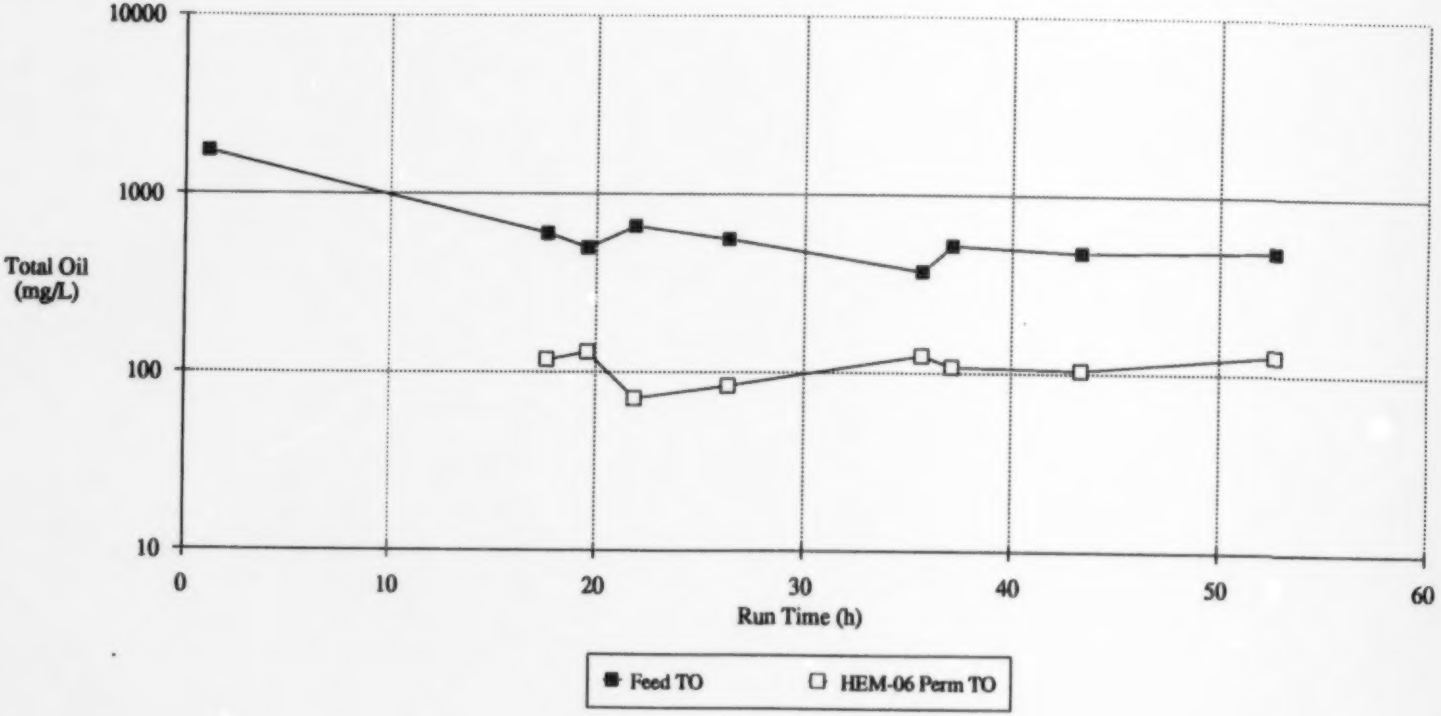
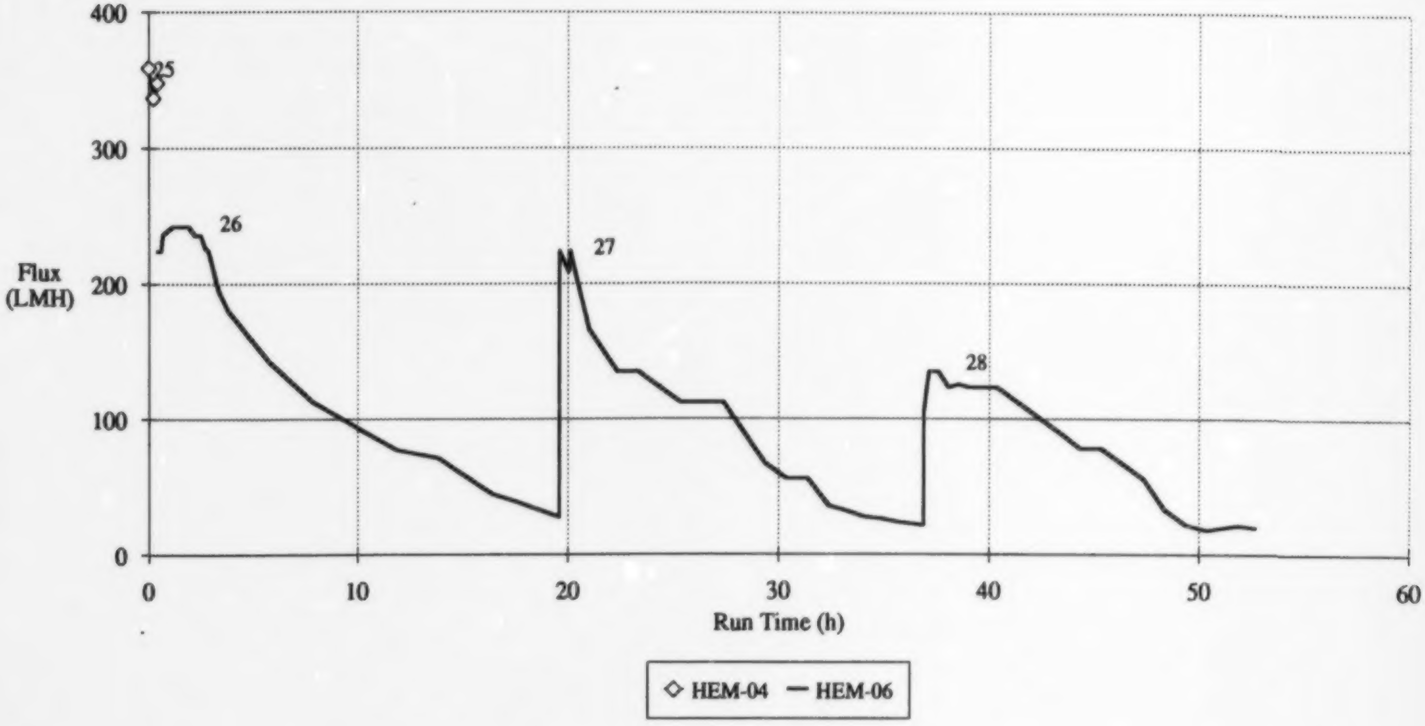


FIGURE 3-10
Site "A," Stage III, Flux Versus Run Time for the HEM-04 and HEM-06 Membranes.



The average flux for the HEM-06 was 120 LMH over 59 hours of run time. The HEM-06 started Run 26 at a flux of approximately 225 LMH and gradually decreased to roughly 25 LMH over 20 hours of operation. A similar trend is noted in Runs 27 and 28. Cleaning with 4XMC-3 following Run 26 indicated excellent flux rejuvenation, whereas the same cleaning after Run 27 was approximately half as effective. What may be more important is the progressively shorter run time to reach 25 LMH following each cleaning. Signs of irreversible fouling are apparent from these results.

Stage III Discussion

The ultrafiltration performance in Stage III appears better than earlier stages. The specific reason for the improvement is not clear as the process was improved in two ways: 1) MBM operation and 2) prefiltration. In theory, MBM, compared to RBM, operation will reduce the rate of increase in membrane feed oil concentration and should theoretically reduce the rate of flux decline due to oil fouling (see Section 3.3.4). The long term continuous operation used in MBM runs would also reduce frequent shut downs and thus cool downs causing solidification of foulant on membrane surfaces. Prefiltration aided Stage III operation as well by removing suspended particles suspected of fouling the membrane. It is clear the bag filter is removing something from the feed, since after 60 hours of use the prefilter required changing as it was coated with oil solids. However, the effectiveness of prefiltration could not be quantified, indicating more study is needed in this area. Despite feed pretreatment, irreversible fouling is still apparent through a decreasing flux versus time relationship.

3.3.4 Membrane Surface Fouling

Several of the membranes returned from field testing were visually analysed for surface fouling. Photographs of cross-section samples of the membranes tested at Site "A" are shown in

Plates 3-1 to 3-4. Each plate illustrates a representative sample of the module inlet membrane tube and module outlet membrane tube. The two samples are compared since there is a significant difference, particularly for HEM-04. The reason for the difference is speculated to be a result of a higher flux at the begin of the module than at the end (due to higher pressure at the inlet than at the outlet), and therefore a greater solids layer buildup at the inlet. Whatever the reason, it is quite clear surface fouling is occurring when we compare the tested membranes with an unused HEM representing all new membrane types, Plate 3-1. The foulant seems to be slightly different in appearance for each membrane, as well as different extents of fouling. One of the rather amazing results of the surface analysis is the significant presence of foulant on the HEM-04 after only 0.4 hours of run time on produced water. As well, the high flux noted for the HEM-04 before it was taken off-line, suggesting the foulant shown in Plate 3-2 did not effect flux appreciably. The appearance of the foulant HEM-04 was similar to what the operator scraped from the HEM-02 (not shown) during Stage II, suggesting upset conditions may have reoccurred during Stage III. Another interesting observation are the black marks on the HST-03, indicate free oil was present in the feed and attaching at the membrane surface.

3.4 Site "A" Summary

The results from Site "A" testing indicated the effective rejection of total oil by the UF membrane. In general, the membranes rejected approximately 90% of the TO in the membrane feed and discharged a permeate containing no insoluble oil. This performance clearly indicates a comparable, if not better, separation technology than conventional produced water treatment. If consideration is also given to the key advantages of the membrane process over conventional technology, such as: a finite separating barrier that will eliminate down-stream upsets, a modular design that allows for easy system expansion and improved system control since no demulsifier chemical is required, the potential for the produced water UF membrane process is significant.

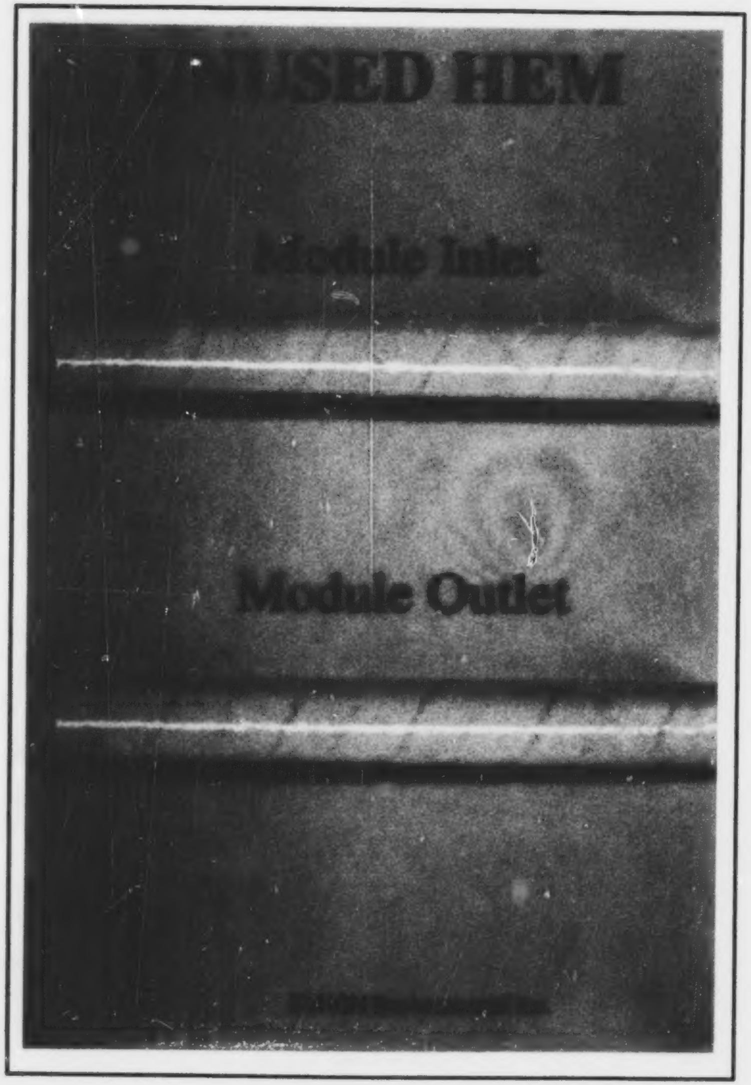

USED HEM
Module Inlet
Module Outlet

PLATE 3-1

Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of an unused HEM Membrane. Total Run Time of 0 Hours.

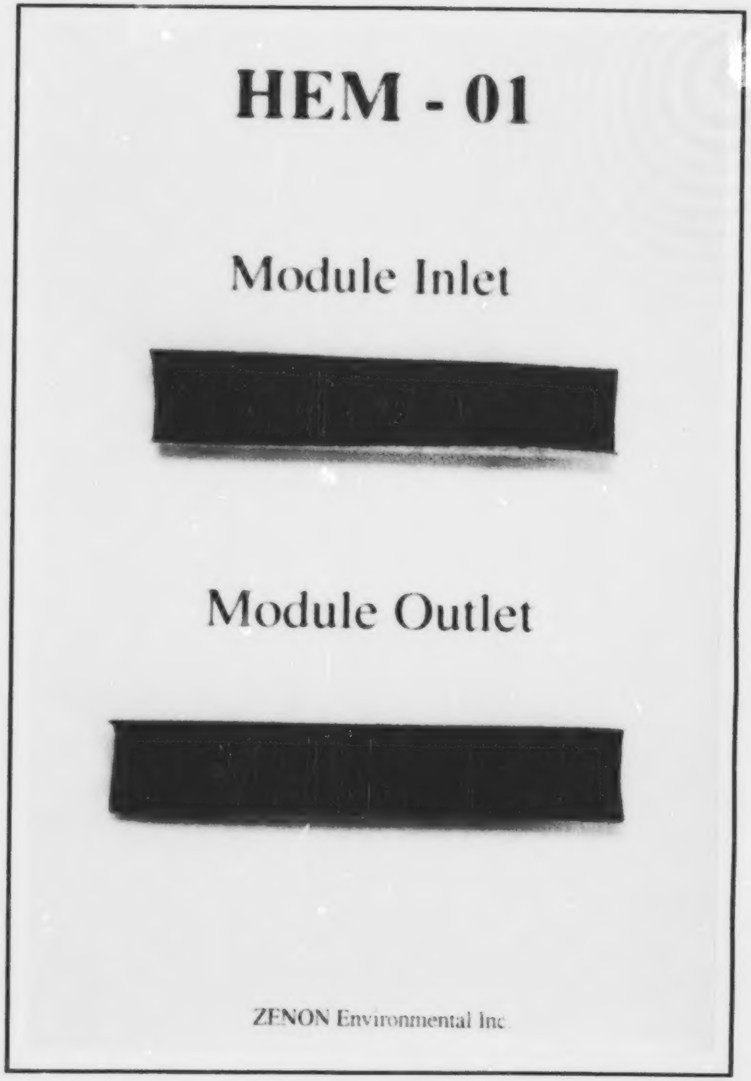

HEM - 01
Module Inlet
Module Outlet
ZENON Environmental Inc

PLATE 3-2

Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HEM-01 Membrane. Total Run Time of 34 Hours.

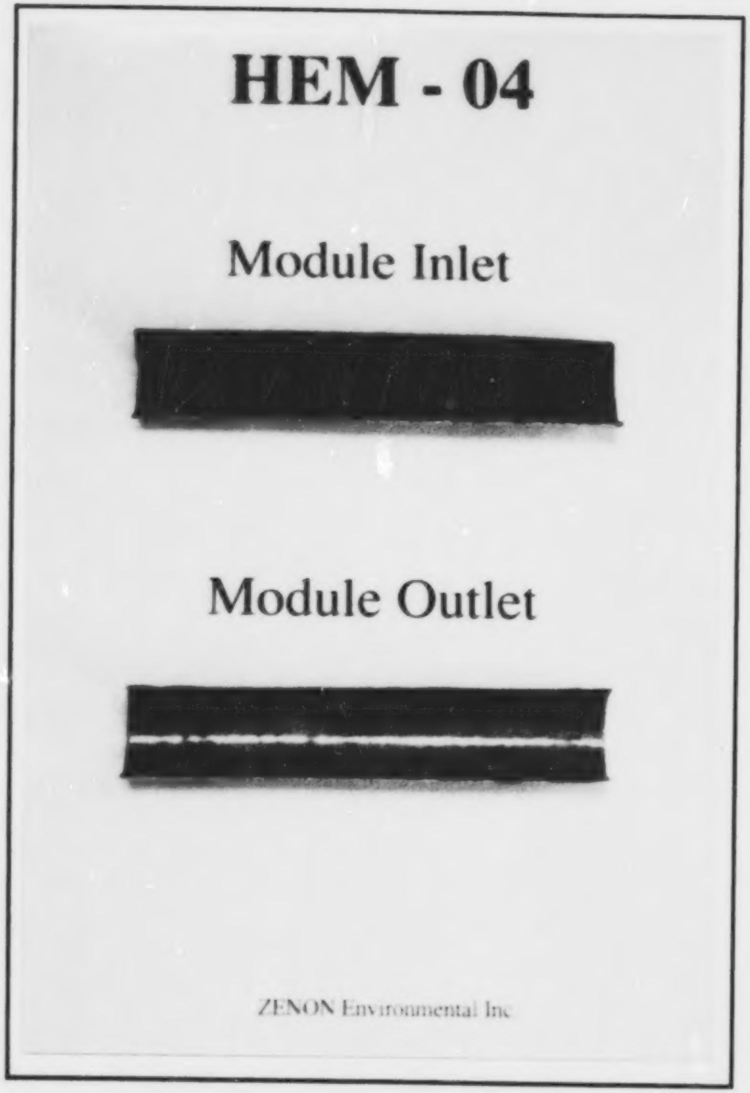

HEM - 04
Module Inlet
Module Outlet
ZENON Environmental Inc

PLATE 3-3
Photograph of Module Inlet and Module Outlet
Cross-Cut Tube Samples of the HEM-04 Membrane.
Total Run Time of 0.4 Hours.

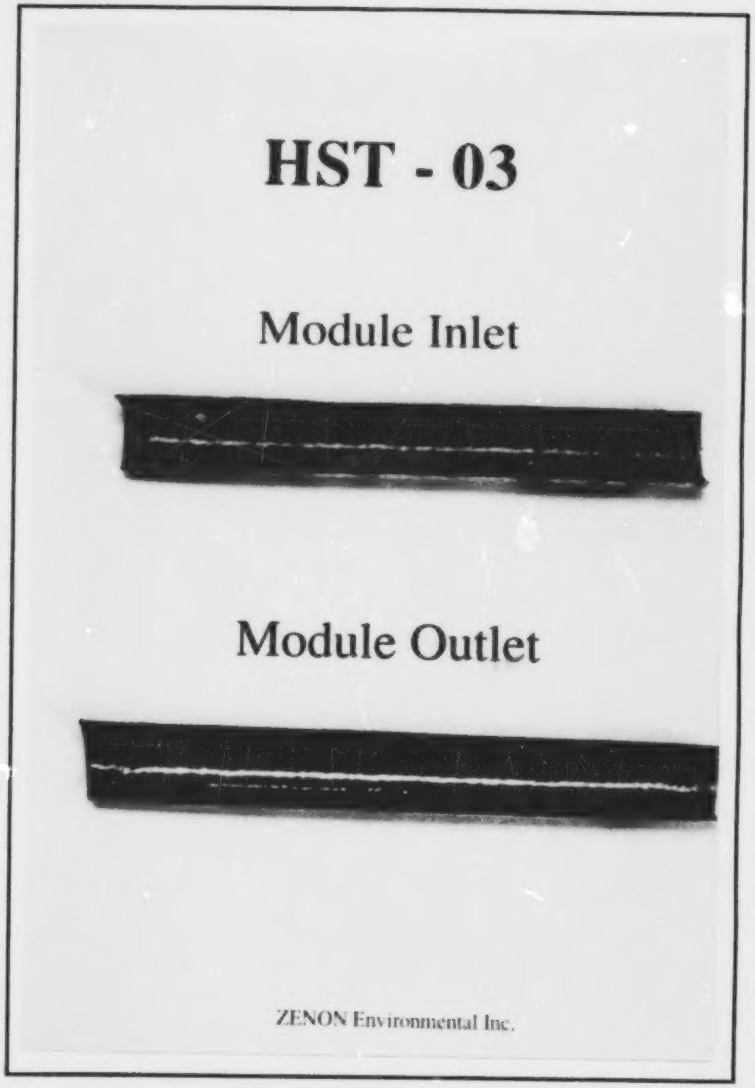

HST - 03
Module Inlet
Module Outlet
ZENON Environmental Inc.

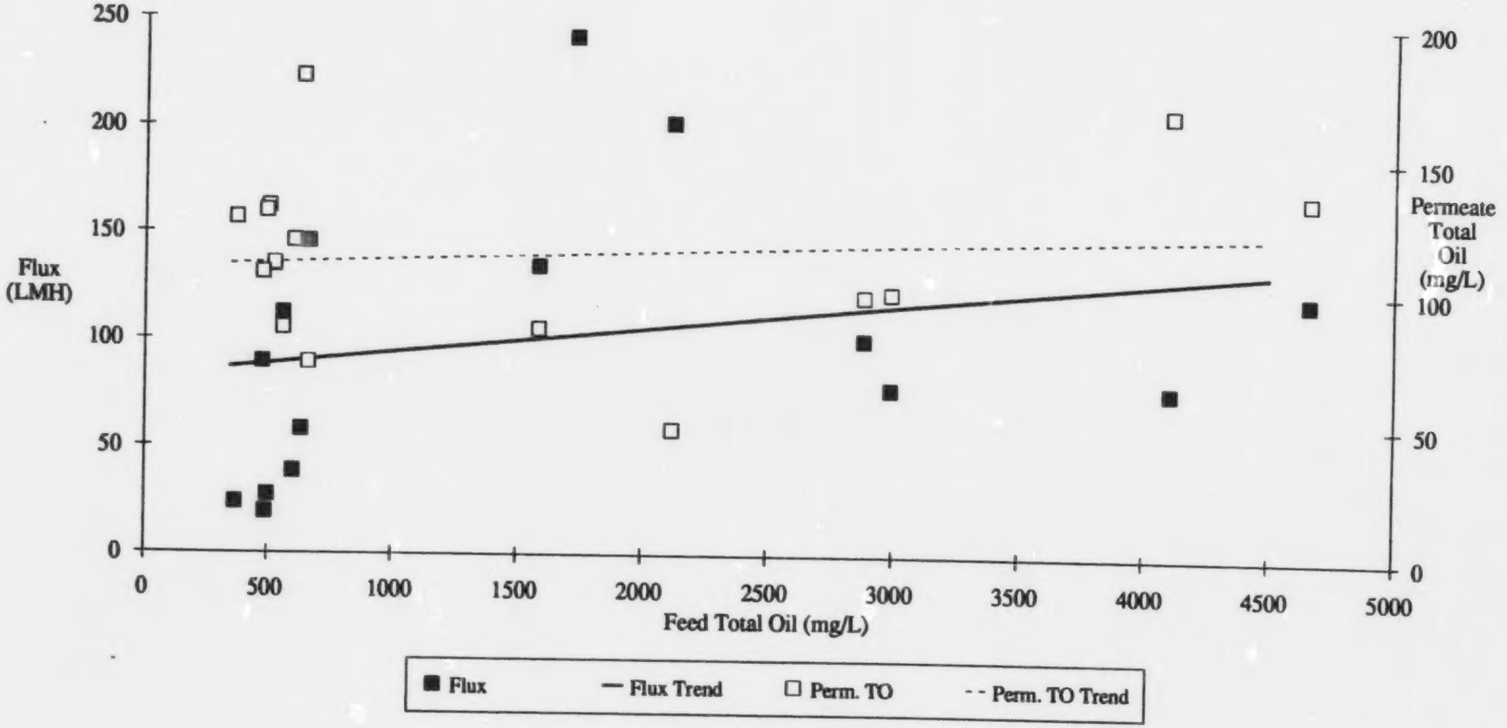
PLATE 3-4
Photograph of Module Inlet and Module Outlet
Cross-Cut Tube Samples of the HST-03 Membrane.
Total Run Time of 20 Hours.

The results from Site "A" also indicate a problem with the control of membrane fouling and therefore maintaining membrane flux rates. The flux rates from a new membrane are expected to decrease in the earlier stages (a conditioning effect) and then reach a stability of foul/clean cycles. It is important to point out that most membrane fouling, although often resulting in a flux decrease, does not pose a irreversible impact on the membrane. Chemical cleaning will normally remove the foulant from the membrane and restore the lost flux (i.e. reversible fouling). Membrane cleanings with 4XMC-3 during the latter stages of Site "A" tests were more effective at restoring flux than the weaker strength MC-3 cleanings in earlier stages. However, the 4XMC-3 cleanings gave less than complete restoration in most cases and, as a result, membrane flux rates diminished over time (e.g. HEM-06). The fouling problem is a difficult one, as more aggressive cleaning formulas pose a potential of harming membrane components used in fabrication, and more frequent cleanings, although a possible short term solution, will not solve long term fouling. Pretreatment of the feed to remove the foulant would be the most progressive approach since it eliminates the problem. The bag-filter used in Stage III holds some promise, although it is not clear whether it is removing the foulant of importance in the feed. More testing will help determine the success of reducing fouling with prefiltration.

TO does not appear to play a significant role in the membrane flux or rejection for the HEM type membrane, based on information presented in Figure 3-11. The flux and permeate data from the HEM-01 and HEM-06 membranes were compiled and graphed against TO in the membrane feed. A least squares linear regression for both flux and permeate data in Figure 3-11 indicates fairly horizontal trend line, suggesting a weak relationship with TO. This is surprising, as in many UF applications we see a slight decrease in flux and an increase in permeate contaminants as feed contaminant concentrations increase. Possibly the relationships are too subtle to be illustrated with the small data base used for these graphs. As well, the error variance in the data compared to the

FIGURE 3-11

Site "A," Average HEM Flux and HEM Permeate Concentration of Total Oil Versus Membrane Feed Concentration of Total Oil (HEM-01 and HEM-06 data).



trend lines is very high at 2222 for the flux line and 4381 for the permeate. Just the same, the effect is welcome in this application as it ensures a relatively stable product quality and quantity basically independent of oil concentration (at least in the range considered). More on the feed effects to membrane performance are discussed in Section 4.3.3.

It is important to note the several membranes damaged beyond repair as a result of module failure during Site "A" testing. Some of these membranes were on-line long enough for data to be collected (i.e. HST-03 and HEM-04), whereas others were damaged quickly before data could be collected (i.e. HEM-03, HSC-02 and HEM-05). Several of these failed modules were studied at ZENON and the cause of each failure was related to problems in the mechanical sealing of the module housing to the membrane. The cause of the sealing problems was determined to be heat distortion of the plastics used in the manufacture of the modules. Although ZENON's standard membrane modules have a proven track record with regard to high temperature operation (<80°C), the replaceable tube modules (used in this study) were specially developed for produce water UF field testing, and are considered to be a prototype. The frequent assembly and disassembly of these modules in the field, combined with high temperature operation and the rapid heating and cooling of the modules (due to the cold operating environment), lead to the distortion of the module components and the ultimate loss of mechanical seal. More temperature resistant materials are available for module fabrication and are being explored now. However the implementation of new materials would take additional research and development; well outside the scope of this study. As a short term resolution, disassembly of modules in the field was discontinued for Site "B" tests.

4.0 SITE "B" RESULTS AND DISCUSSION

4.1 Feed Characterization

Two samples of the Skim Tank influent feed source were tested for particle size distribution and Zeta potential. The first sample, taken January 1989, had a average particle size of 2.16 µm; with a standard deviation of 1.51, and a Zeta potential of -16.5 mev; with a standard deviation of 3.0. The second sample, taken January 1990, had a average particle size of 2.56 µm; with a standard deviation of 2.23, and a Zeta potential of -15.7 mev; with a standard deviation of 1.7. Little difference is noted in the particle size and Zeta potential of the two Site "B" samples. In comparison to Site "A" produced water," Site "B" indicates a Zeta potential approximately 50% less negative and a particle size approximately 20% larger.

In addition, the emulsion stability of the first sample was tested for effects of pH, age, and heat. The results were similar to Site "A" tests, in that there were no significant changes as the pH was increased above control and coalescence and settling occur in the acidic range. In addition, the sample turned dark with age and was not obviously affected by the heat. Refer to Appendix F for experimental data.

4.2 Experimental

Site "B" tests are divided into two stages and are represented in Table 4-1.

TABLE 4-1
Description of Test Stages at Site "B"

Stage	Period	Runs	Source Feed	Mode
IV	19-Jan-90 to 10-Feb-89	1 to 11	Skim Tank Influent	MBM
IV	25-Jul-89 to 11-Aug-89	12 to 16	Skim Tank Influent	MBM
V	23-Oct-89 to 05-Feb-90	17 to 33	Skim Tank Influent	FBM

Approximately half of the runs at Site "B" were MBM and the other half were FBM. The MBM runs were concentrated to an approximate 95% volume reduction, and the continuous FBM runs were stabilised at an approximate 95% volume reduction.

The produced water at Site "B" was not associated with significant amounts of hydrogen sulphide (H_2S), unlike Site "A." As a result, lids on the UF system tanks could be open and sampling done freely. Samples of membrane feed and permeate were taken daily (except weekends) whereas source feed, and before and after the prefilter, were sampled less frequently.

The UF system operating conditions for Site "B" are outlined in Section 2.3.2 and can be reviewed in Appendix C.

Changes were made to the method of membrane cleaning at Site "B." Rather than circulating cleaning solution from the process tank - as was done at Site "A" - the cleaning solution was circulated from a separate 200 L tank. The tank was interconnected with a pump and plumbing to channel cleaning solution directly to the membrane module and therefore exclude the pumping of cleaning solution through the support plumbing of the system. This new cleaning approach was designed to overcome the potential of spending cleaner on oil-fouled plumbing parts and tanks rather than on the fouled membrane.

Cleanings were conducted as required, but were commonly done once a week. All of the cleanings at Site "B" involved 4XMC-3, and some of the cleanings involved sponge balls. The sponge balls are a mechanical form of membrane cleaning and were used to help remove fine solids thought to be fouling the membrane surface. Specific usage of sponge balls is documented in Appendix C run data, as well as discussed in Section 4.3.

4.3 Results

The results from Stage IV and Stage V are discussed independently and summarised at the end of this section. A focus is placed on the results of membrane flux and membrane rejection characteristics. Operating results are taken from data in Appendix C and present in graphs of flux versus run time. Numbers along the flux versus time plot line indicate two things: the reference number for the run and the time of membrane cleaning. Membrane rejection of TO is taken from Appendix D and is presented in Tables 4-2 and 4-3. Rejection of other parameters, such as TDO, TSM, TDS, and ions, are also reported in Appendix D but not presented in the text. In short, all of the membranes tested where expected to, and did, reject virtually no TDO, all TSM, no TDS, and no ions. This performance is expected given the level of MWCO of each of the membranes tested (see Table 2-1).

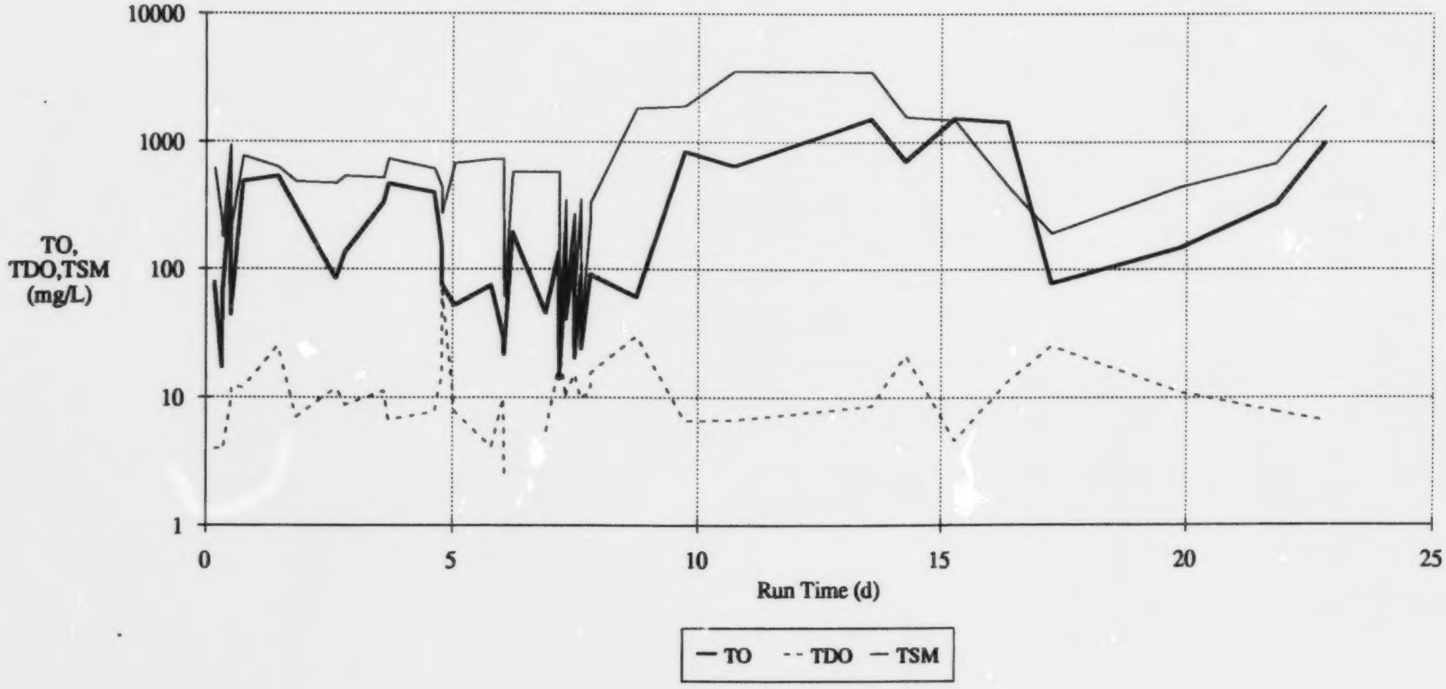
4.3.1 Stage IV

Conditions

The membrane feed changed as illustrated in Figure 4-1, for the 29 run days of Stage IV. The TO fluctuated considerably throughout this period, whereas the TDO remained relatively stable. Once again, the TSM follows a similar fluctuation trend as the TO, indicating some interdependence.

The process goal of Stage IV testing was to establish regular MBM operation. In theory, the oil concentration in MBM operation should gradually increase in the process tank as fresh feed is introduced to the system at the same rate as permeate is removed. When the desired volume reduction is reached (determined by the volume of permeate produced) the MBM run is complete. However, the membrane feed oil concentration during Stage IV was often lower than the predicted oil concentration based on volume reduction (e.g. TO should be approximately 9 fold of the TO in

FIGURE 4-1
Site "B," Stage IV, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO), and Total Suspended Matter (TSM) Versus Run Time.



the feed at 90% volume reduction). One definite source of this discrepancy is the variability of the source feed TO concentration, therefore effecting the prediction of membrane feed TO concentration. Another, speculated, source of discrepancy is the formation of free oil in the process tank not collected in "grab" sampling. Some free oil was often noted on in the process tank (indicated by a sheen on the liquid surface), but it was difficult to quantify - the free oil likely broke out from the feed emulsion as a result of concentrating the oil in the process tank. Despite these two sources of discrepancy in the oil balance, volume reduction was still used to indicate the end of an MBM run - often 95% volume reduction.

Equipment control problems during Stage IV (Runs 1 - 16) made MBM impossible to conduct without operator assistance. As a result, many of the MBM runs were interrupted on weekends and overnight to switch the UF system into a stability mode. The specific runs where this switch occurred are clearly indicated in the log sheets in Appendix C. However, it is assumed the impact of stability did not affect the flux trend of any of the membranes tested.

As indicated in Table 4-1, there was approximately a 24 week interruption in Stage IV testing at Site "B". The interruption occurred because of low EOR production rates and therefore insufficient volumes of produced water for continuous UF processing. The testing was stopped until additional wells were "steamed" and brought on-line to increase production rates. The UF system was brought back on-line on July 25, 1989 to complete Stage IV tests.

Membrane Performance

Four membranes were tested during Stage IV; the HEM-07, HEM-08, HST-04, and HSC-03. A summary of TO rejection and average flux performance for each membrane tested is shown in Table 4-2. A graph of feed and permeate TO versus run time for each membrane is shown in Figure

4-2. In addition, a graph of flux versus run time results for the HEM series are shown in Figure 4-3 and the same results for the HST and HSC are shown in Figure 4-4. Details of membrane performances during Stage IV are considered below.

TABLE 4-2
Site "B," Stage IV, Average Flux and Rejection Summary

Membrane Type	Total Run Time (h)	Average Flux (LMH)	sd	Average TO in Feed (mg/L)	sd	Average TO in Perm. (mg/L)	sd	Average % TO Rejection	sd
HEM-07	554	195	96	308	399	10	13	86	35
HEM-08	180	153	62	736	544	12	8	95	8
HST-04	185	179	71	406	337	21	11	79	20
HSC-03	115	333	45	333	358	51	65	75	26

HEM-07:

The average TO permeate quality from the HEM-07 was 10 mg/L, corresponding to an average rejection of 86% of the TO fed to the membrane. From Figure 4-2, the HEM-07 permeate TO concentration fluctuates considerably during the first 200 hours of testing, and then stabilises about 10 mg/L throughout the remainder of testing.

The average flux for the HEM-07 was 195 LMH over 326 hours of run time. From Figure 4-3, the HEM-07 started with a markedly higher flux value than HEM's tested at Site "A." The HEM-07 started at a flux of 460 LMH and quickly dropped to 250 LMH, despite repeated efforts to clean. The HEM-07 flux oscillated about 250 LMH for approximately eight days of run time through Runs 5 to 11. This stable performance was extremely encouraging in comparison to previous tests, it demonstrated high fouling resistance and good response to cleaning. However,

FIGURE 4-2
Site "B," Stage IV, Membrane Feed Concentration of Total Oil and HEM-07, HEM-09, HST-04, and HSC-03 Permeate Concentration of Total Oil Versus Run Time.

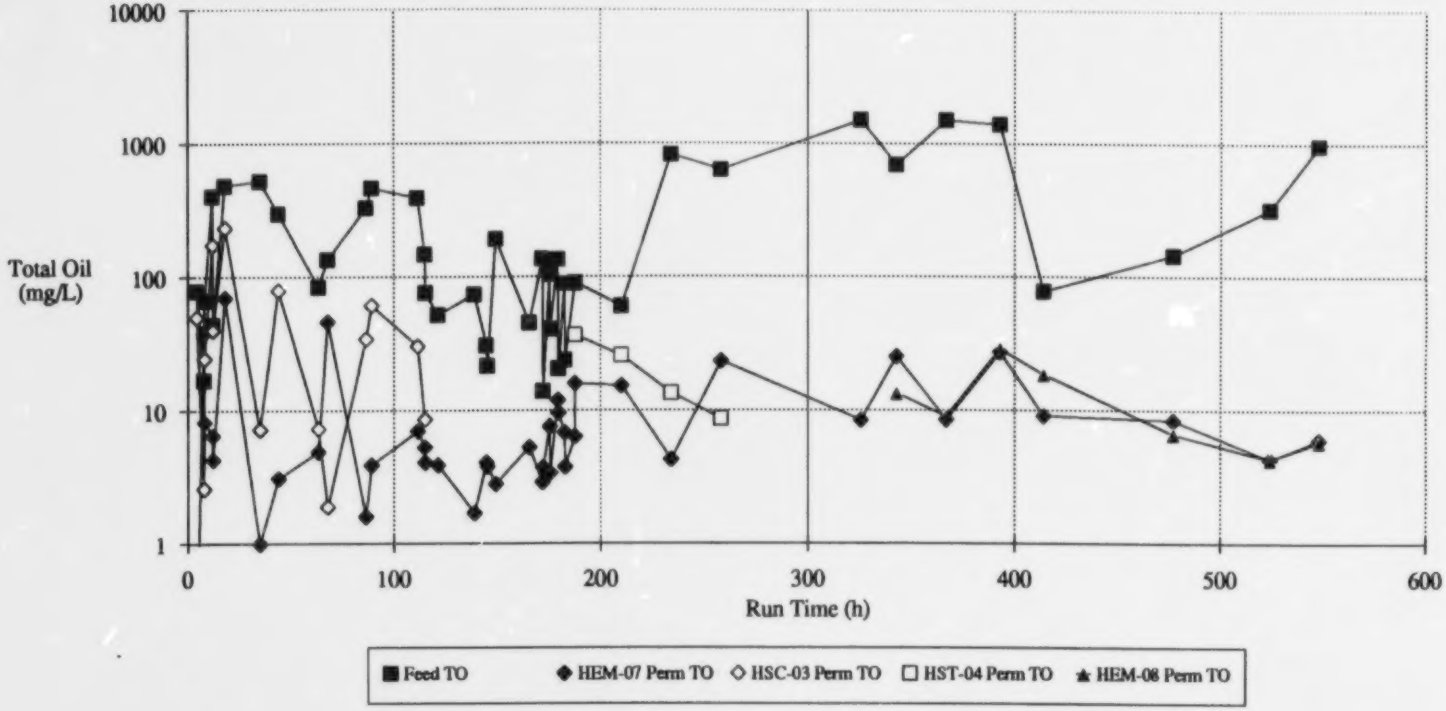


FIGURE 4-3

Site "B," Stage IV, Flux Versus Run Time for the HEM-07 and HEM-08 Membranes.

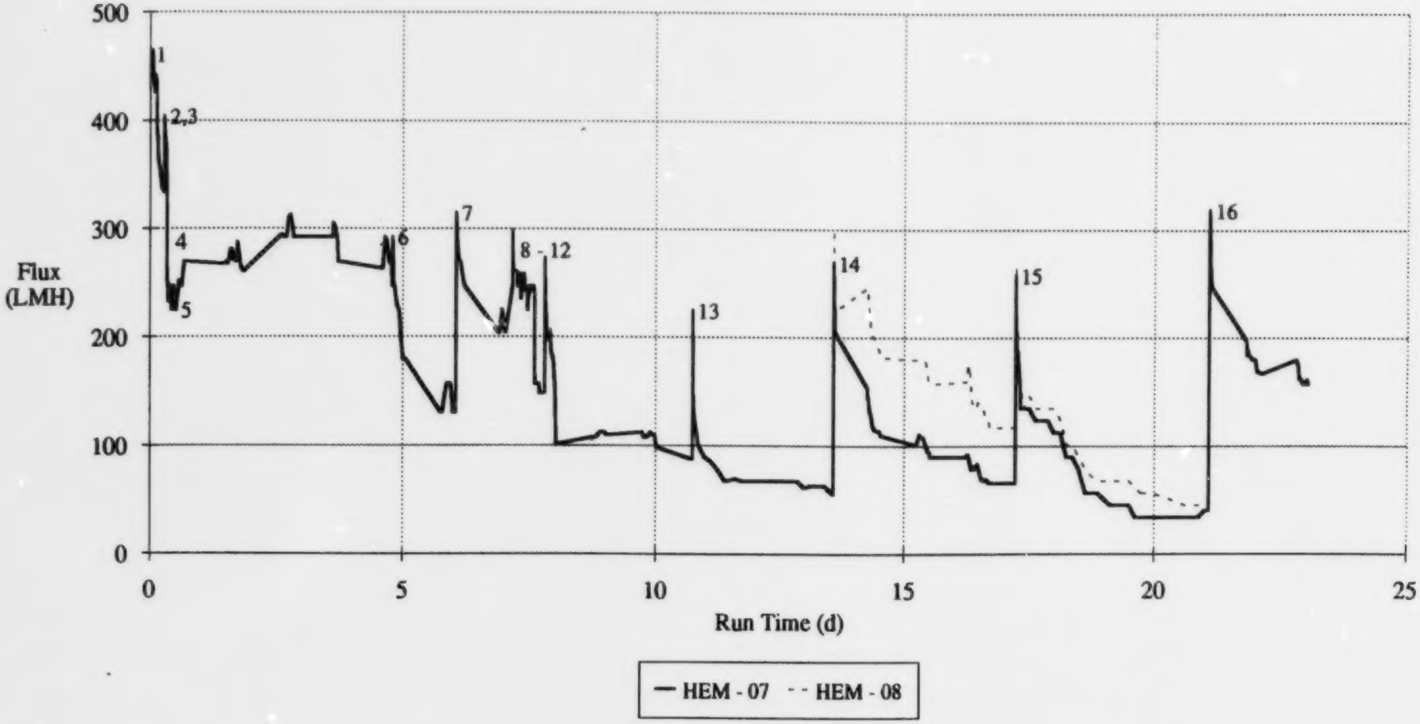
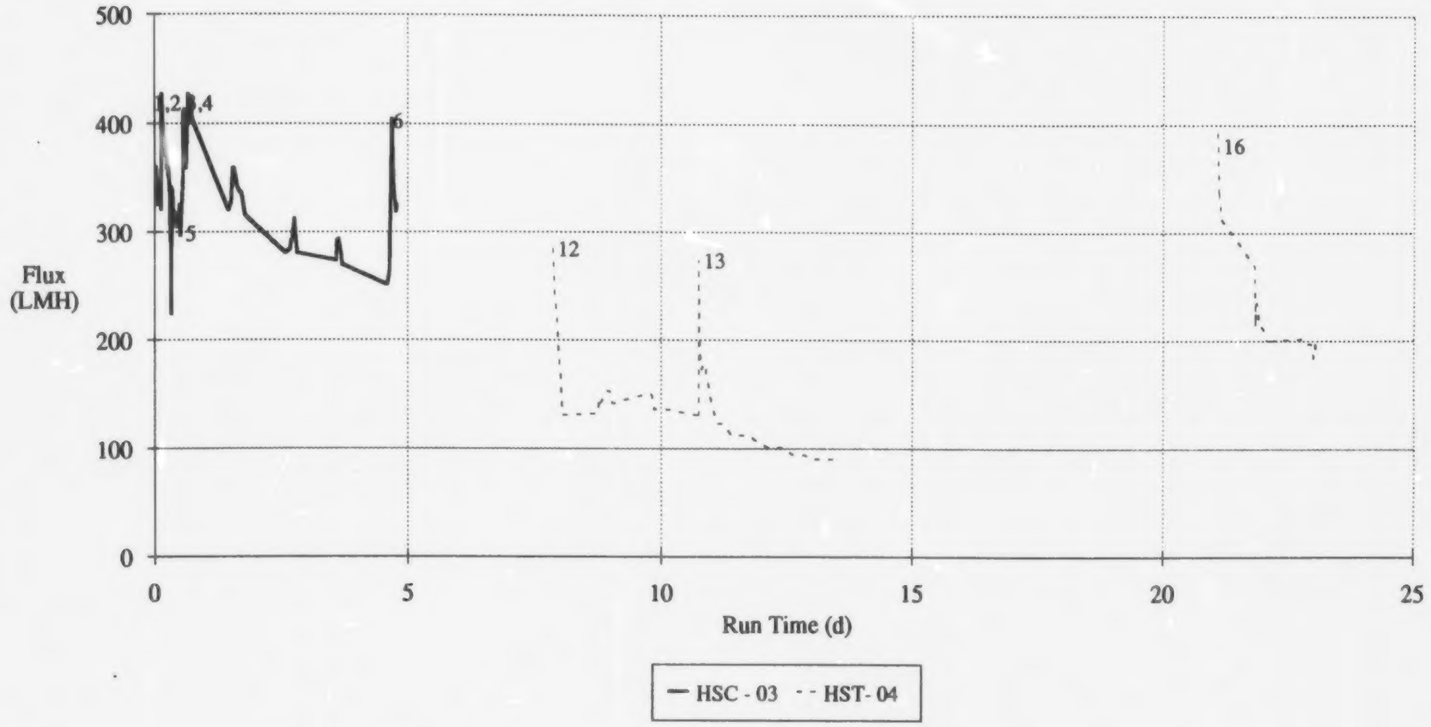


FIGURE 4-4
Site "B," Stage IV, Flux Versus Run Time for the HSC-03 and HST-04 Membranes.



this good flux performance diminished between Runs 12 and 15, with little response to cleaning, and then dramatically returned during Run 16. The reasons for the change in flux performance are not obvious, but are likely linked to the changes in the feed.

HEM-08:

The average TO permeate quality from the HEM-08 was 12 mg/L, corresponding to an average rejection of 95% of the TO fed to the membrane (see Figure 4-2).

The average flux for the HEM-08 was 153 LMH over 180 hours of run time. This lower flux performance, over a shorter run time, suggests the HEM-08 was exposed to more significant fouling during its testing than the HEM-07 was over its initial 180 hours of run time. From Figure 4-3, we see the HEM-08 was put on-line for Runs 14 and 15 and the flux, although slightly higher, closely follows the trend of the HEM-07 during this period. This behaviour is important to note for two reasons: 1) it indicates the HEM-08 and HEM-07 are comparable and thus reproducible as an HEM type membrane and 2) the age of HEM membrane has little effect on the extent of membrane fouling.

HST-04:

The average TO permeate quality from the HST-04 was 21 mg/L, corresponding to an average rejection of 79% of the TO fed to the membrane (see Figure 4-2). Despite the lower TO rejection from the HST compared to HEM membranes, the quality of permeate from the HST-04 is still comparable to (if not better than) the treated effluent from conventional treatment systems. The lower rejection is not expected based on MWCO information in Table 2-1, although the different surface chemistry of the HST from the HEM may be a role.

The average flux for the HST-04 was 179 LMH over 185 hours of run time. From Figure 4-4, the HST-04 flux followed a similar overall pattern as the HEM-07 flux but at a flux approximately 30% higher. The higher flux can not be solely attributed to the HST-04, since the HEM-07 and been on line for a longer period of time, but it certainly appears to exhibited better flux potential. The HST-04 was taken off-line after Run 12 so the HEM-08 could be tested . Further testing of the HST-04 was done in Stage V.

HSC-03:

The average TO permeate quality from the HSC-03 was 51 mg/L, corresponding to an average rejection of 75% of the TO fed to the membrane (see Figure 4-2). As with the HST-04, the permeate quality for the HSC-03 meets process objectives. The lower rejection compared to the other membranes tested may be connected to the higher MWCO for the HSC-03 (refer to Table 2-1).

The average flux for the HSC-03 was 333 LMH over 115 hours of run time. The flux at the start of Run 5 was roughly 425 LMH and gradually declined to 250 LMH over the course of Run 5. The HSC-03 responded well to cleaning after Run 5 and appeared to out performing many of the other membranes tested. Unfortunately, the HSC-03 module failed shortly into Run 6 and the module was taken off line. Later examination at ZENON indicated the cause of failure was due to a loss of seal caused by thermal stress on the plastic module housing.

Stage IV Summary

The membrane performance was similar for all membranes tested in Stage IV. The UF permeate quality was equal to (or better than) what could be accomplished with conventional treatment. Membrane flux was variable and dependent on membrane age and run time, but no obvious advantage can be seen for selecting one membrane type over another. A time-weighted average flux of 200 LMH and TO rejection of 85% summarizes the performance of the four membranes tested during Stage IV.

The membrane performance in Stage IV was generally better than Stages I through III. Although membrane rejection was roughly the same for Stage IV as it was for earlier stages, membrane flux rates started approximately 40% higher for almost all membranes tested. In addition, the fluxes remained higher for longer periods of run time. The improved flux performance might be attributed to the continuous nature of the MBM operation (see Section 3.3.3, Stage III Discussion) or the improved cleaning techniques, but is more likely attributed to a difference in produced water characteristics. More discussion on this effect is in Section 4.3.3.

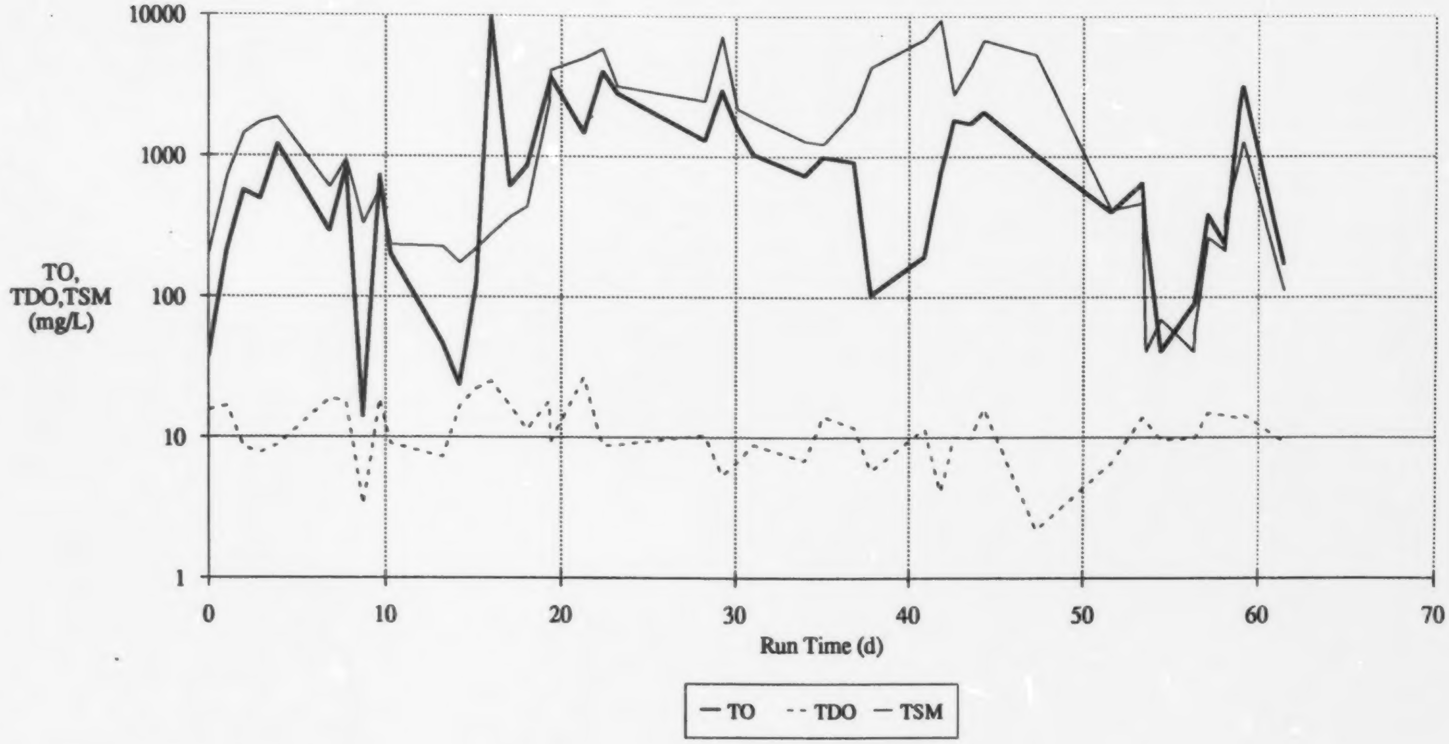
Despite the general flux improvements in Stage IV, fouling still appears to be a problem. A gradual flux decline is obvious in all three membranes tested and no one membrane type seems any more resistant to fouling than the other two. Although cleaning is obviously doing something to reverse the fouling effects, the result is brief and becomes less effective over time. More needs to be learned in the area of membrane fouling, membrane cleaning, and possibly feed pretreatment in order to proactively deal with this problem.

4.3.2 Stage V

Conditions

The membrane feed changed as illustrated in Figure 4-5 for the 62 run days of Stage V. The levels of TO and TDO remain much the same as they were in Stage IV, whereas the TSM was generally higher in Stage V than in Stage IV. The higher level of TSM is thought to be a result of clay noted in the feed source. The breakdown of TSM for several runs during Stage V indicated a hydrocarbon fraction of approximately 20% and the balance of insoluble material. This

FIGURE 4-5
Site "B," Stage V, Membrane Feed Concentration of Total Oil (TO), Total Dissolved Oil (TDO), and Total Suspended Matter (TSM) Versus Run Time.



hydrocarbon value is considerably lower than the 60% values noted in Stage IV hydrocarbon analysis. Later analysis of membrane surface foulants gave further validation to the presence of clay, see Section 4.3.3.

Operation in Stage V successfully demonstrated long term FBM UF operation, however operating problems did occur. Two problems made this type of operation difficult to control: 1) the wide and frequent swings in the source feed oil concentration made it almost impossible to maintain the membrane feed oil concentration at a desired level (the objective of FBM operation), and 2) changing permeation rates required frequent manual adjustment of the concentrate bleed rate. An operator was not always available to to make this adjustment. The first problem is inherent to the process application and would require a bleed control based on an on-line measurement of feed oil concentration. The second problem could be dealt with easily through an automated concentrate bleed line control linked to membrane permeation rates. Despite these control problems, 95% volume reduction was generally achieved throughout the FBM runs. As in Stage IV testing, some of the runs were switched over to stability on weekends. The specific runs where this switch occurred are clearly indicated in the log sheets in Appendix C, however, as already mentioned, the impact of stability did not appear to affect the flux trend of any of the membranes tested.

Experiments at a higher pH were done in Runs 24, 25, and 26. The objective was to improve the stability of the oil emulsion by bringing more oil into emulsion and thus reducing the presence of free oil). The pH of the feed was adjusted by adding 5N NaOH to the source feed, and was adjusted from a pH of approximately 8 to a pH of approximately 9, 10, and 11 successively during Run 24, and controlled at pH 9 during Runs 25 and 26. All of the pH adjustment work changed the appearance of the feed to a muddy water consistency from a brown water with suspended material. The change in appearance suggested a more stable oil emulsion had been produced. Unfortunately, other changes, uncontrollable, were affecting the process at the same time of the pH experiments and the results are therefore difficult to interpret (see Section 4.3.2, Membrane Performance).

A foaming agent was injected into several oil producing wells on January 16, 1990, corresponding to Run 27, and may have interfered with UF performance. The foaming agent, Chevron SD1020, was injected by the oil producers in an effort to reduce "steam communication." The chemical injections continued through the remainder of Stage V testing and on several occasions the foam was detected in membrane permeate when conducting TO extraction analysis. The presence of SD1020 in the permeate corresponds to some extremely poor results in both membrane flux and membrane rejection in Runs 27 through 33. The foam is an anionic sulphonated surfactant and, by itself, is generally not considered a problem for ZENON's ultrafiltration membranes. However, when the surfactant is present with other components such as clay and oil in produced water the effects are unknown. More study is needed to consider the effects of this potential foulant.

An upstream process control problem on January 19, Run 28, caused the exposure of the UF system to "produced oil" (approximately 95% oil in water) as a feed source. Level switches failed to sense the product level in the Site "B" separator and, as a result, "produced oil" was fed to the ultrafiltration process tank where it was fed to the one membrane on-line at the time (HEM-08). It is estimated the membrane processed "produced oil" for approximately eight hours before the operator was available to intervene. The membrane was cleaned thoroughly and put back on-line, but the cleaning result indicated poor rejuvenation as the membrane was extremely fouled. These specific ultrafiltration membranes are not designed to tolerate oil concentration of this extreme, so it is necessary in future experiments for instrumentation to be on-line to detect the presence of high oil concentrations in the membrane feed.

Membrane Performance

Six membranes were tested during Stage V; the HEM-07, HEM-08, HEM-09, HST-04, HST-05, and HSC-04. A summary of the TO rejection and average flux performance for each membrane tested is shown in Table 4-3. A graph of feed and permeate TO versus run time for each membrane is shown in Figure 4-6. In addition, a graph of flux versus run time results for the HEM series are shown in Figure 4-7 and the same results for the HST and the HSC series are shown in Figure 4-8. Details of membrane performances are considered below.

TABLE 4-3
Site "B," Stage V, Average Flux and Rejection Summary

Membrane Type	Total Run Time (h)	Average Flux (LMH)	sd	Average TO in Feed (mg/L)	sd	Average TO in Perm. (mg/L)	sd	Average % TO Rejection	sd
HEM-07	1140	64	56	1438	1786	13	7	94	18
HEM-08	364	49	79	1237	1692	17	4	90	12
HEM-09	41	339	135	838	193	14	3	99	0
HST-04	690	87	82	551	449	11	7	91	17
HST-05	265	105	72	884	1141	172	224	51	52
HSC-04	336	98	120	2815	2560	17	4	98	3

HEM-07:

From Table 4-3, the average TO permeate quality from the HEM-07 was 13 mg/L, corresponding to an average rejection of 94% of the TO fed to the membrane. From Figure 4-6, the HEM-07 permeate TO concentration is fairly consistent throughout the run time despite large fluctuations in the feed TO concentration. Compared to the HEM-07 performance in Stage IV, the average rejection of TO is up slightly from 86% and the average flux is almost 67% lower. The

FIGURE 4-6

Site "B," Stage V, Membrane Feed Concentration of Total Oil and HEM-07, HEM-08, HEM-09, HST-04, HST-05, and HSC-04 Permeate Concentration of Total Oil Versus Run Time.

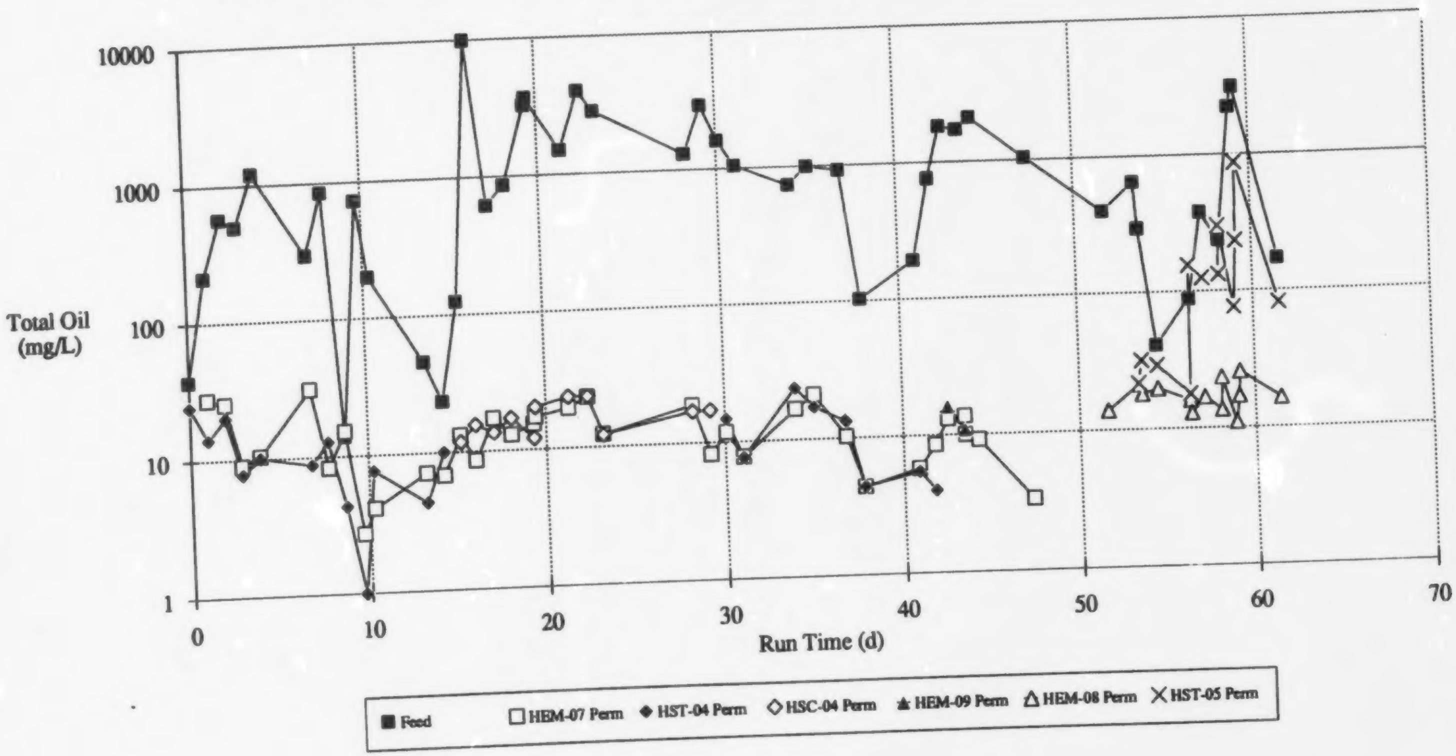


FIGURE 4-7
Site "B," Stage V, Flux Versus Run Time for the HEM-07, HEM-08, and HEM-09 Membranes.

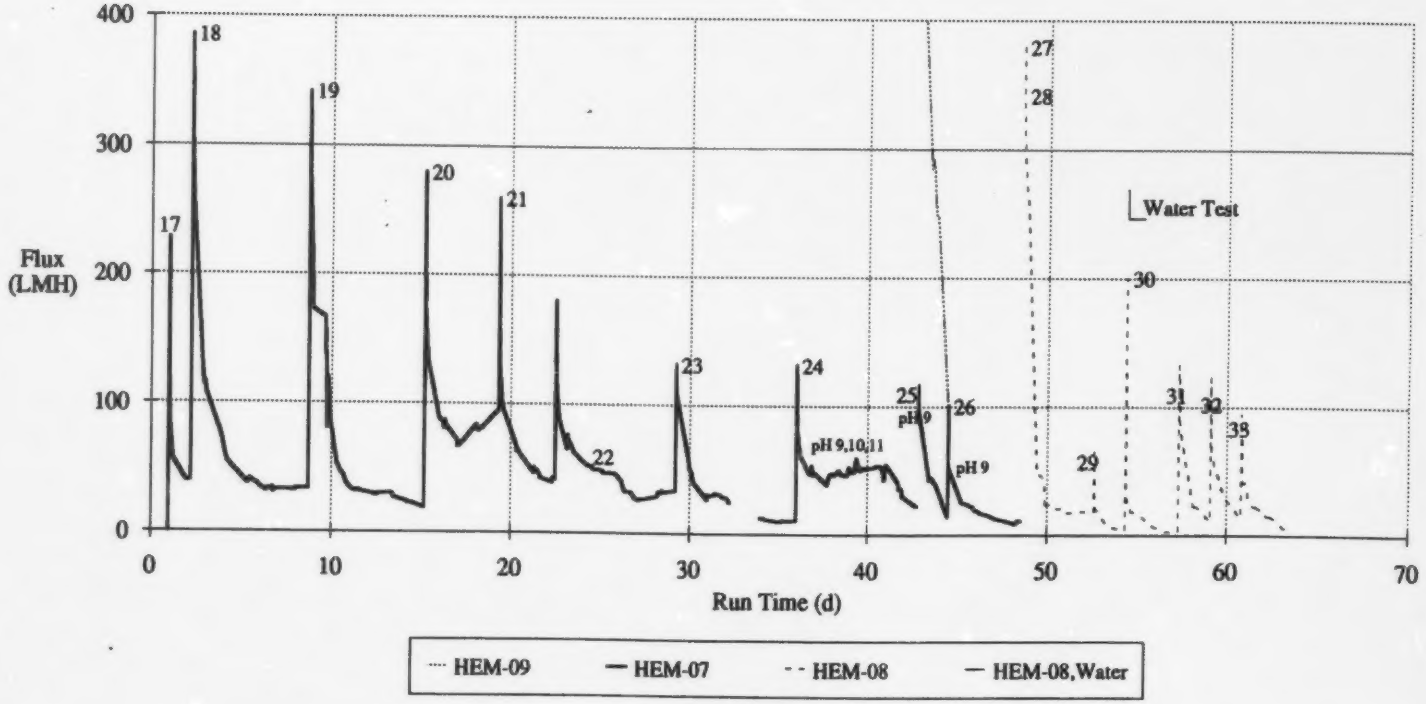
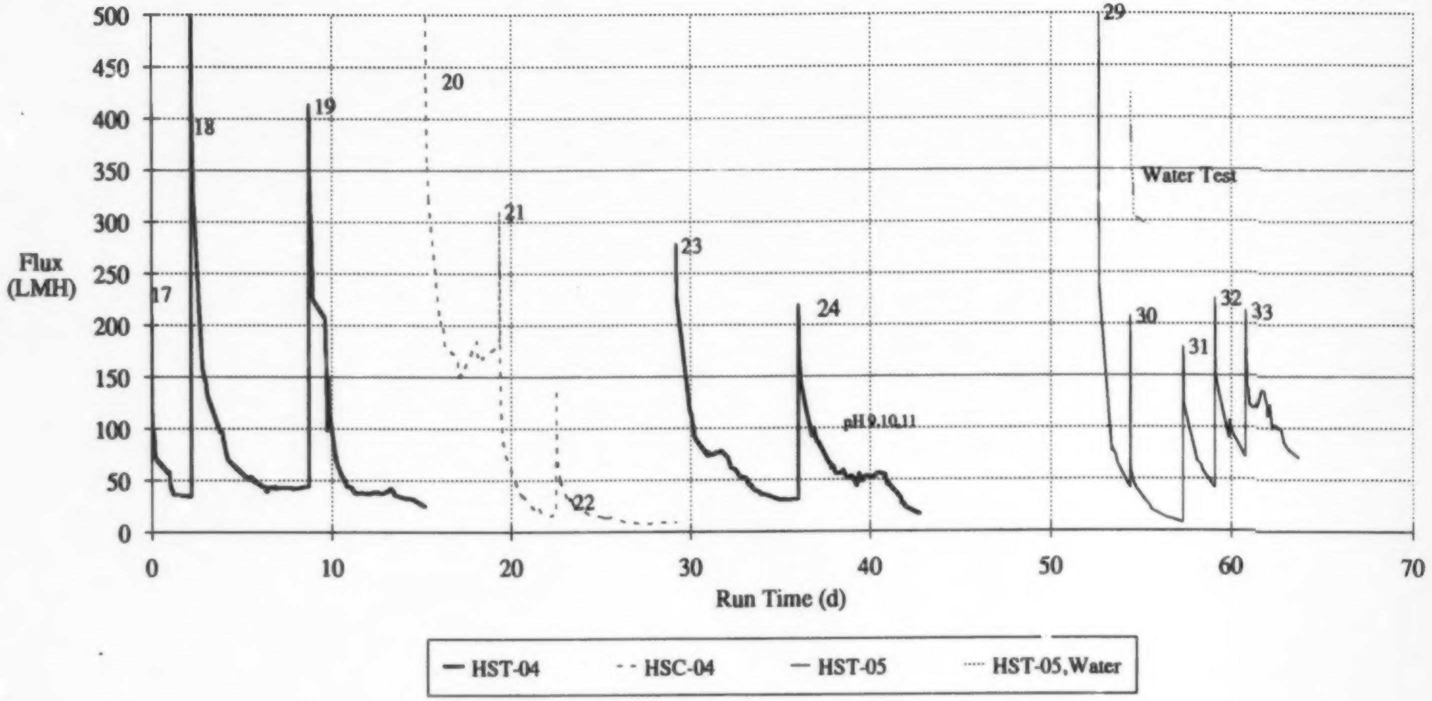


FIGURE 4-8
Site "B," Stage V, Flux Versus Run Time for the HST-04, HST-05, and HSC-04 Membranes.



reason for the lower flux is likely fouling related due to a higher average TO concentration in the feed as well as a notable increase in TSM (refer to Appendix D).

From Table 4-3, the average flux for HEM-07 was 64 LMH over 1140 hours of run time. From Figure 4-7, the HEM-07 flux gradually decreased through Runs 17 to 22. Cleanings following these runs indicated a positive flux response, but the level of response diminished with each new cleaning. A pH 9 and pH 10 adjustment were made during in Run 24 and they both appeared to slightly improve flux stability equally. A further adjustment to pH 11, however, corresponded to a sharp decrease in flux - possibly a result of fouling caused by precipitating too much dissolved solids. Additional experiments at pH 9 in Runs 25 and 26 indicated no positive improvements in flux performance.

Further pH experiments in the field were terminated due to the weak response of membrane flux to an increase in pH. Results of the pH work are unclear, as it was later learned that process conditions changed dramatically during this test (see Section 4.3.2, Conditions).

Sponge balls were later used following Run 25 and Run 26, in an effort to improve membrane cleaning, but the sponge balls appeared to make little difference to the cleaning effectiveness. The HEM-07 was removed from testing as a result of a module seal failure damaging the membrane following Run 26. The failure was determined to be an effect of mechanical sponge ball cleaning - not the result of thermal stress - and therefore the use of sponge ball cleaning was terminated from the test programme.

HEM-08:

From Table 4-3, the TO average permeate quality from the HEM-08 was 17 mg/L, corresponding to an average rejection of 90% of the TO fed to the membrane. From Figure 4-6, the HEM-08 permeate TO concentration is also fairly consistent showing little relationship to the feed TO concentration.

From Table 4-3, the average flux for HEM-08 was 49 LMH over 364 hours of run time. From Figure 4-7, the initial flux of the HEM-08 decreased quickly during Runs 27 and 28 and then appeared to stabilise. A water flux test was conducted prior to Run 30 to see if flux reduction may have been a result of membrane compaction, the results are also shown in Figure 4-7. The water flux indicates a slight decrease followed by 24 hours of stability; greatly different from process. This result suggests flux decline for the HEM-08 is chiefly due to the feed source and not due to membrane compaction.

HEM-09:

The TO average permeate quality from the HEM-09 was 14 mg/L, corresponding to an average rejection of 99% of the TO fed to the membrane. This rejection result is based on only two sample analyses, as the HEM-09 was only tested for a short period of time.

The average flux for HEM-09 was 339 LMH over 41 hours of run time. From Figure 4-7, the HEM-09 flux started Run 25 (at pH 9) at a flux of 400 LMH and rapidly decreased to a final flux of 100 LMH. This flux decrease is much more rapid than seen in earlier stages of the testing, and clearly indicates a more persistant foulant is present during Stage V. The HEM-09 failed due to mechanical damage caused by sponge ball cleaning at the end of Run 25, and was taken off-line.

HST-04:

The average TO permeate quality from the HST-04 was 11 mg/L, corresponding to an average rejection of 91% of the TO fed to the membrane (refer to Figure 4-6). Compared to the HST-04 performance in Stage IV, the average rejection of TO is up slightly from 79% and the average flux is 51% lower.

The average flux for HST-04 was 87 LMH over 690 hours of run time. From Figure 4-8, the HST-04 flux followed a similar trend to the flux of the HEM-07 during most of Stage V. Slightly higher flux values are noted for the HST-04 after it was reinstalled into the system following Run 22. The HST-04 performed similar to the HEM-07 during the pH adjusted Run 24, and was taken off-line.

HST-05:

The average TO permeate quality from the HST-05 was 172 mg/L, corresponding to an average rejection of 51% of the TO fed to the membrane (refer to Figure 4-6). The HST-05 permeate quality was lower than normally seen for any of the previously tested membrane. It is unclear whether the low rejection is a result of a membrane problem or a change in the feed stream. Although the HEM-08 performed as expected throughout this period, a feed stream change would seem unlikely unless sensitive to the HST-05 alone. It is possible the foaming agent, described in Section 4.3.2 Conditions, was causing interference with rejection.

The average flux for HST-05 was 105 LMH over 265 hours of run time. It was installed in the system as a new membrane (at the start of Run 29) and fouled dramatically, similar to the HEM-08. Cleaning was generally more effective for the HST-05 then the HEM-08 through this period, and additional cleaning following Runs 31, 32, and 33 appeared to be even more effective at rejuvenating flux. A water flux test was conducted on the HST-05 as well (see Figure 4-8), and it indicated a similar response to the HEM-08, confirming flux reduction was coming from the feed and not membrane compaction.

HSC-04:

The average TO permeate quality from the HSC-04 was 17 mg/L, corresponding to an average rejection of 98% of the TO fed to the membrane (refer to Figure 4-6).

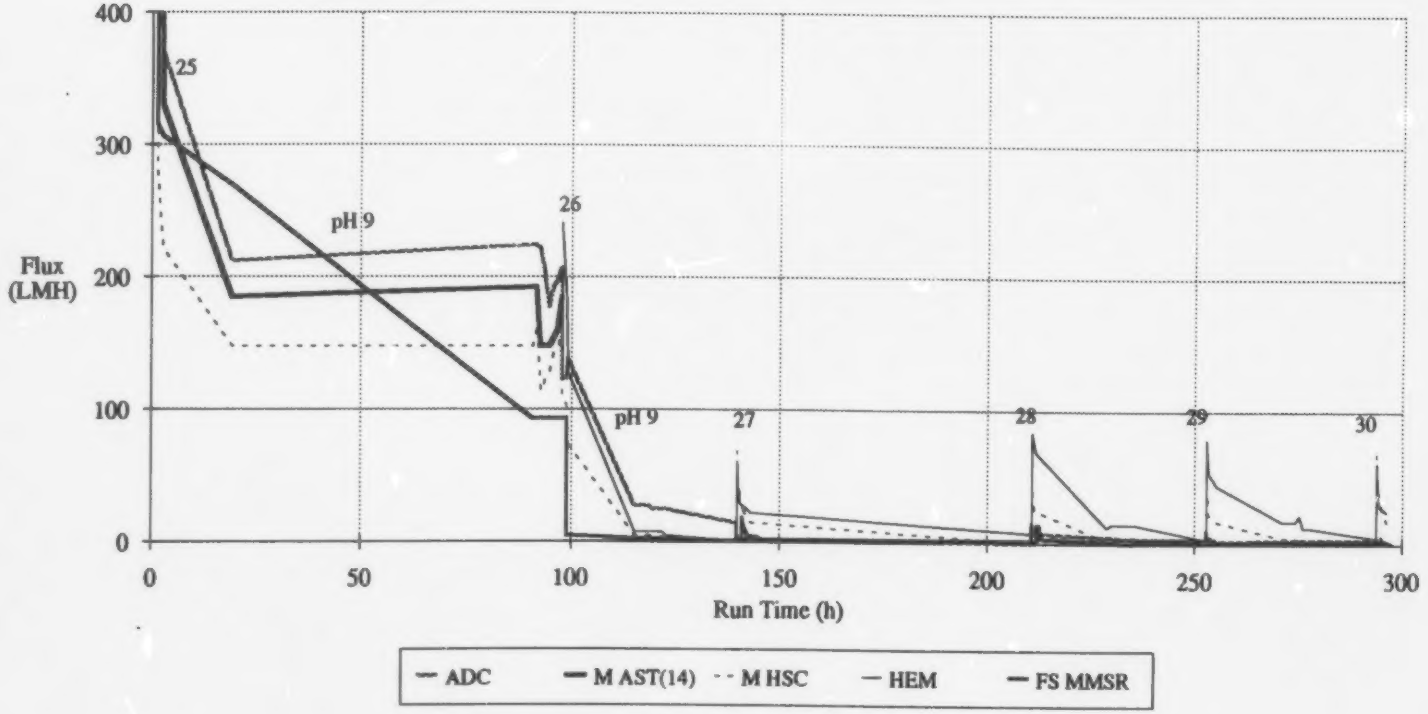
The average flux for HSC-04 was 98 LMH over 336 hours of run time. The HSC-04 had a very low average flux of approximately 10 LMH at the end of Stage V testing. It was installed in the system as a new membrane (at the start of Run 20) and it performed fairly well during Run 20, in comparison to the HEM-07, but then fouled quickly and irreversibly during Runs 21 and 22. Due to the significant fouling, the HSC-04 was taken off line following Run 22 and replaced with the HST-04.

Bench-scale:

In an effort to seek out a better membrane for the produced water application, some additional membrane tests were conducted at the bench-scale level in parallel to the pilot test system. Small tube samples of novel membrane chemistries were tested Although no permeate samples were submitted for analysis, the visual quality of permeate from the membranes was comparable to the pilot work. The flux performance of each of the five membranes tested is shown in Figure 4-9. With the exception of the FS MMSR membrane, all the membranes decreased in the first 20 hours and then showed good signs of stability for 75 hours at a flux of about 200 LMH. However, at Run 26 and onward the flux decreased sharply to nearly zero. The reason for this dramatic flux decrease is speculated to be related to the injection of foaming agent at the well on the corresponding run date

FIGURE 4-9

Site "B," Stage V, Flux Versus Run Time for the New Membrane Types Used in Parallel Bench Scale Tests.



(see Section 4.3.2, Conditions). The results from the first 95 hours of bench-scale tests indicated excellent potential of these new membranes to treat produced water. It is recommended several of these new membranes be tested at the pilot-scale level.

Stage V Discussion

Feed and bleed mode (FBM) operation during Stage V did not clearly indicate improvements over MBM operation. The comparison is not easily made since adverse process conditions effected system performance during Stage V. In principle, the FBM operation is completely continuous and holds the advantage of only requiring shutdown for cleanings. If a relatively stable flux performance can be achieved for long periods of time at a desired volume reduction, FBM operation has advantages in efficiency. However, when fouling is recurrent, such as this application, the more frequent cleaning associated with MBM operation may prove more efficient than FBM.

The results of Stage V tests do not clearly indicate one membrane type to be a better performer than another. Permeate quality was comparable to conventional treatment methods for all membranes. The membrane flux was variable and depended strongly on the run time of the membrane rather than the membrane type.

4.3.3 Membrane Surface Fouling

Several of the membranes returned from Site "B" field testing were visually analysed for surface fouling. Photographs of cross-section samples of the membranes tested are shown in Plates 4-1 to 4-7. As noted and discussed previously for Site "A" samples, a distinct difference can be seen in the module inlet and outlet membrane tubes. Also seen in Site "B" samples are varying degrees and appearances of fouling on the membrane surfaces. An obvious difference from Site "A" samples is the greater presence of free oil attached to the surfaces, particularly on HEM-08 and HST-05.

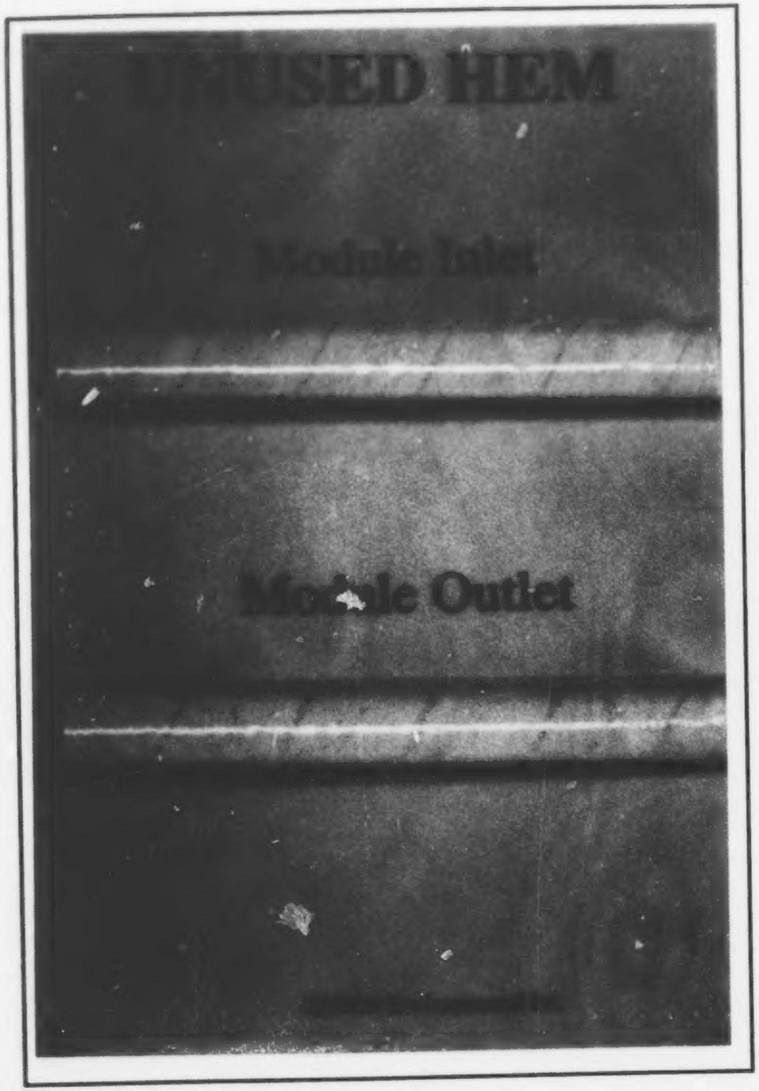

UNUSED HEM
Module Inlet
Module Outlet

PLATE 4-1
Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of an unused HEM Membrane. Total Run Time of 0 Hours.

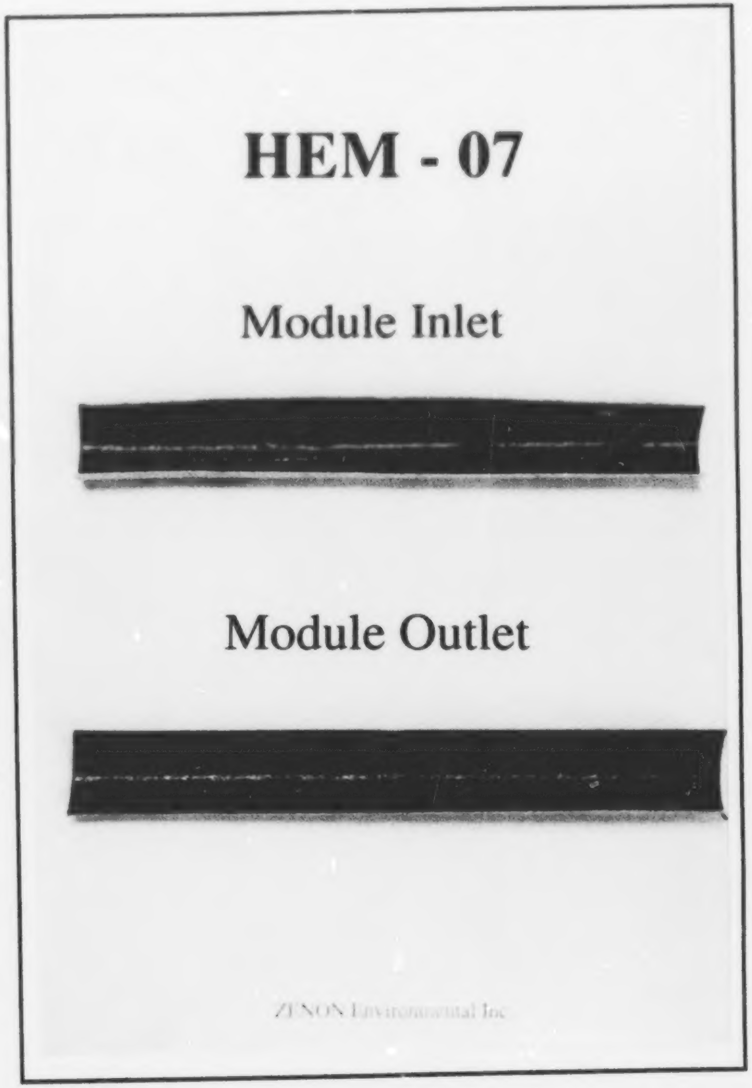

HEM - 07
Module Inlet
Module Outlet
ZENON Environmental Inc

PLATE 4-2
Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HEM-07 Membrane. Total Run Time of 1694 Hours.

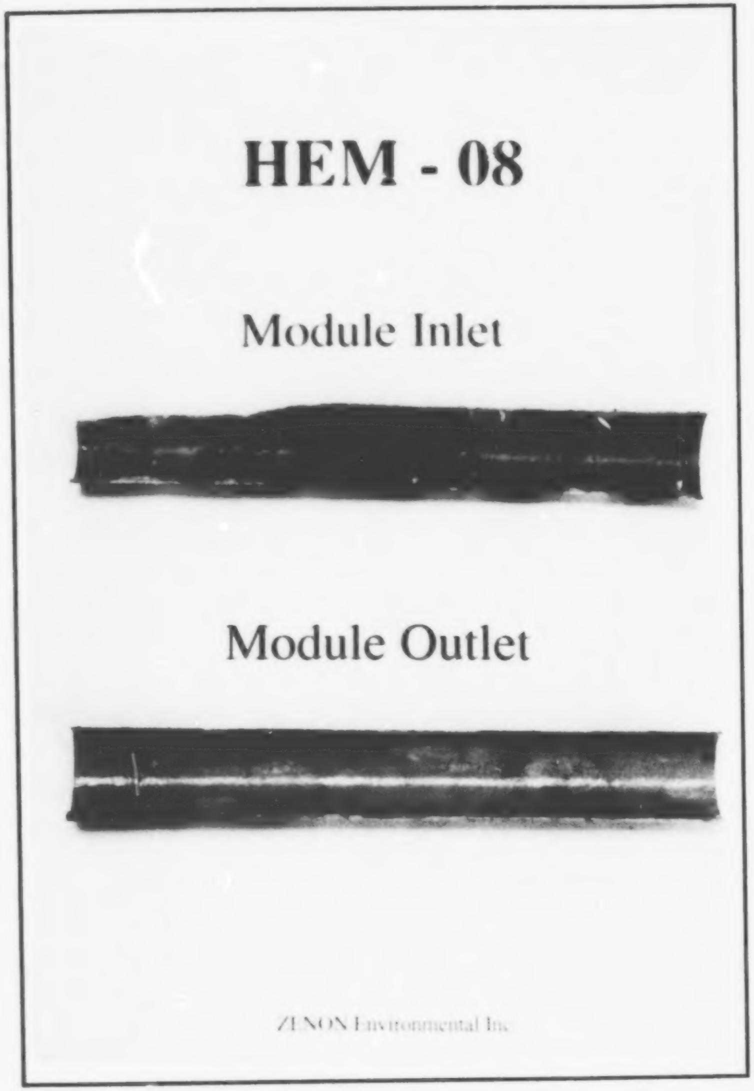

HEM - 08
Module Inlet
Module Outlet
ZENON Environmental Inc

PLATE 4-3
Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HEM-08 Membrane. Total Run Time of 544 Hours.

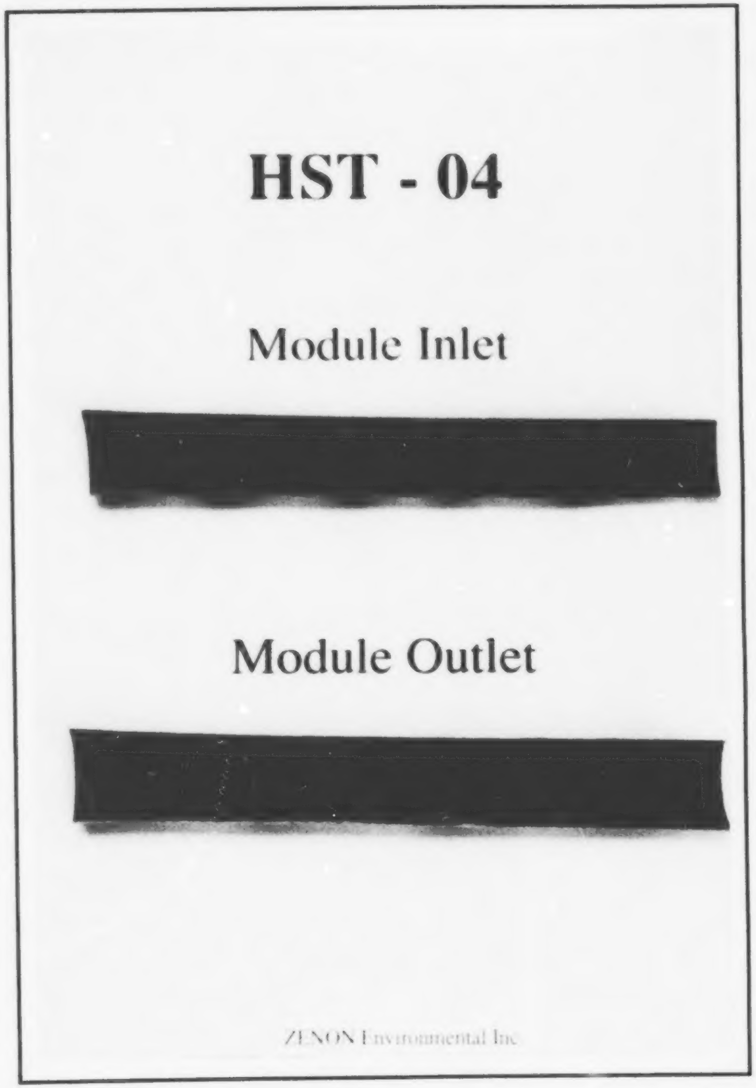

HST - 04
Module Inlet
Module Outlet
ZENON Environmental Inc

PLATE 4-4
Photograph of Module Inlet and Module Outlet Cross-Cut Tube Samples of the HST-04 Membrane. Total Run Time of 875 Hours.

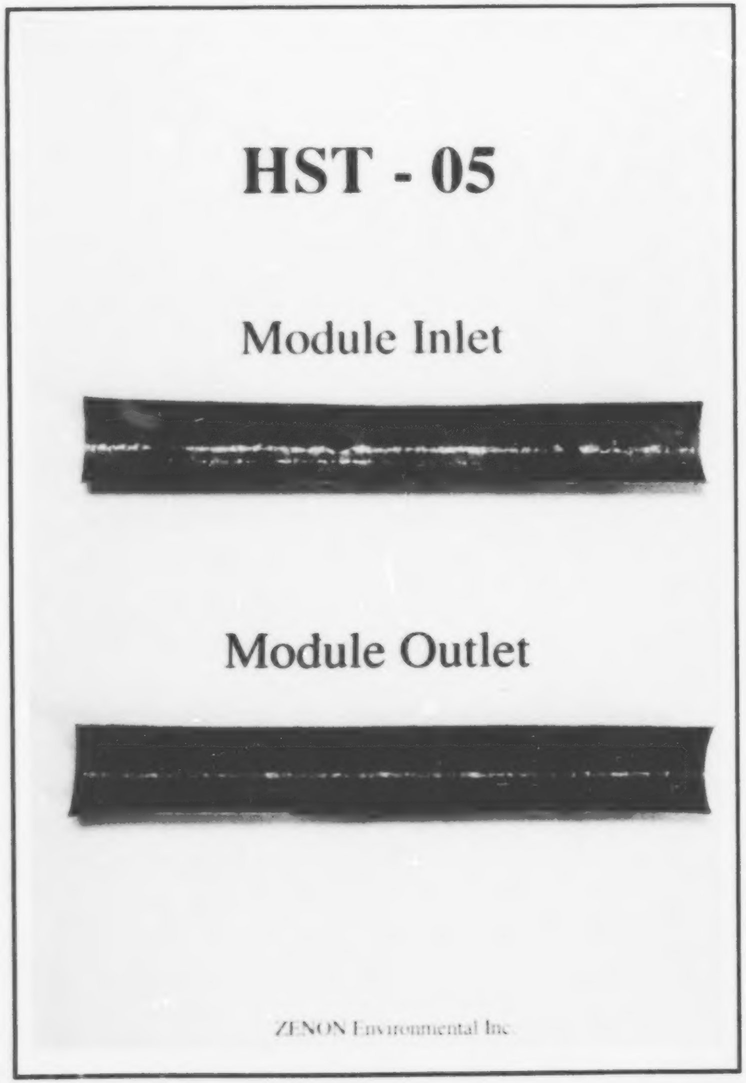

HST - 05
Module Inlet
Module Outlet
ZENON Environmental Inc.

PLATE 4-5

Photograph of Module Inlet and Module Outlet
Cross-Cut Tube Samples of the HST-05 Membrane.
Total Run Time of 265 Hours.

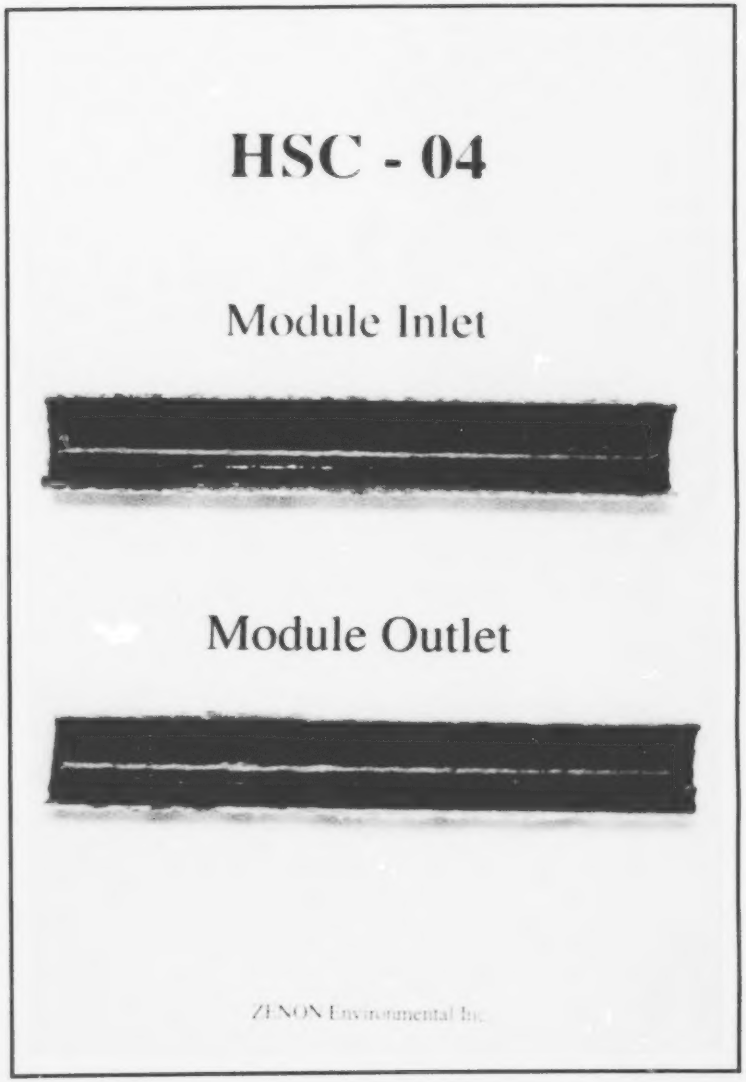

HSC - 04
Module Inlet
Module Outlet
ZENON Environmental Inc.

PLATE 4-6

Photograph of Module Inlet and Module Outlet
Cross-Cut Tube Samples of the HSC-04 Membrane.
Total Run Time of 336 Hours.

These free oil fouled areas appear to have severely damaged the membrane surface, to the point of blistering portions of HEM-08. The back side of HEM-08 (not shown), and other membranes to a lesser extent, indicated a breakthrough of oil to the membrane permeate side. This breakthrough will most certainly reduce flux rates, since water will not pass through hydrophobic oil fouled areas.

The HEM-07 has at least twice the run time of any of the other membranes shown, yet its surface looks less fouled than some of the others. This may indicate a better resistance of the HEM-07 to fouling. If we compare the surface of the HEM-07 to that of the HST-04, the appearance of HST-04 surface is clearly more fouled, despite being tested for roughly half the run time and always in parallel with the HEM-07. The significance may stop there, however, since there is no obvious advantage in flux for the HEM-07 over the HST-04. Possibly the visually surface fouling plays a minor role in flux reduction.

In an effort to learn more about the fouled membrane, a foulant study was done to determine the nature of the foulant visually coating the membranes. Two small coupons of the fouled HEM-07 membrane were removed for experimentation. The average membrane sample surface area was estimated at 4.43 cm^2. A 36 hour Soxhlet extraction (procedure described in Appendix E) with hexane was conducted on two membrane coupons in parallel. The membrane appeared relatively clean following the extraction; suggesting the majority of the foulant was removed. The total average extract mass was measured as 0.1474 g, indicating the foulant coverage on the membrane sample to be $0.0333 g/cm^2$. The extracted mass was filtered to quantify the inorganic suspended solids to be 0.0072 g and the dissolved organic solids to be 0.1472 g. This result is interesting since the hexane extraction was designed to only remove organics from the sample and its clear some inorganics came with the extraction. The inorganics are highly suspected to be clay, possibly suggesting a clay and oil are binding together to form a composite foulant material.

Additional foulant experimentation was done with another coupon of fouled HEM-07 membrane. A 72 hour extraction with 5N NaOH was conducted on the coupon to test for the presence of low molecular weight organic acids (such as Humic acid; a known membrane foulant). Following the experiment (described in Appendix E), the NaOH extract was coloured yellow - suggesting organic acid may be present but the yellow colouring was removed once a liquid extraction was done with MeCl, concluding the yellow colouring was likely from oil rather than organic acids. The experiment proved membrane fouling was likely not due to organic acids in the feed stream.

Surface scrapings from the HEM membrane tested at bench scale were submitted for analysis. The analytical results are shown at the end of Appendix D. From the loss on ignition (LOI) result, roughly 28 percent of the sample was organic in nature and we assume the balance was inorganic. Unfortunately, only 30 percent of the remaining solids were accounted for in the inorganic scan, therefore reducing confidence in the relative quantities of parameters shown. However, the inorganic scan indicates a significant amount of calcium and magnesium to be present, therefore suggesting the potential for calcite and/or dolomite clay compounds to be present. As well, the region of Site "B" is known to contain kaolinite clays[2]. Although surface scrappings were not taken from fouled membranes from Site "A," visual surface analysis suggests similar compounds might be present. A relationship between membrane surface fouling and the presence of clay in the produced water most likely exists, but to learn the extent of the relationship will require addditional study.

4.4 Site "B" Discussion

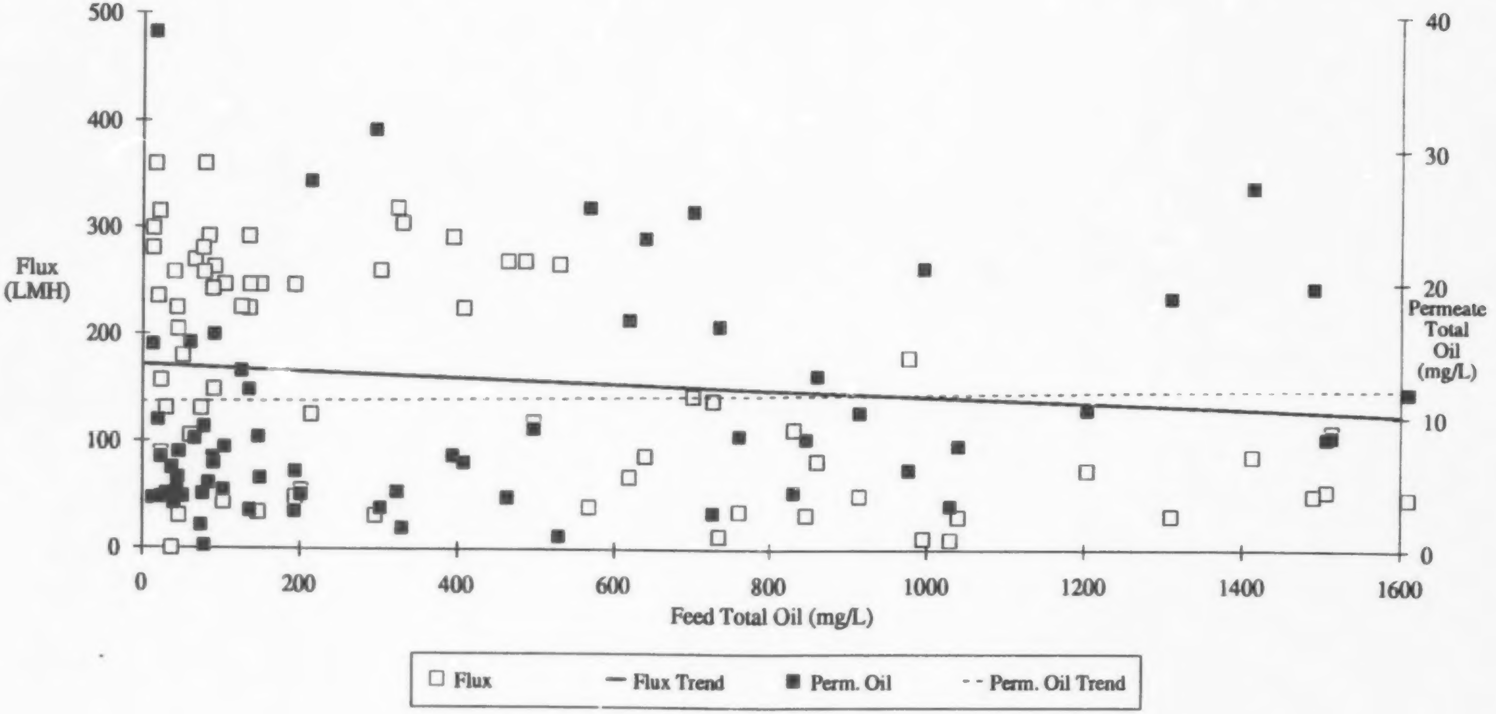
The results from Site "B" testing demonstrated the effective rejection of total oil by the UF membrane. The membranes rejected approximately 85% of the TO in the membrane feed and discharged a permeate containing no evidence of insoluble oil. As already discussed in Section

3.3.3, membrane separation technology can clearly provide a treated effluent quality comparable to conventional treatment equipment. In addition, membrane processing holds the unique operating advantage of insensitivity to TO upsets in the feed. This insensitivity is illustrated in a plot of HEM-07 flux and permeate TO versus membrane feed TO shown in Figure 4-10. Least squares relationships were used to calculate trend lines through the data and are also plotted on Figure 4-10. The trend lines indicate a flux decrease of approximately 35% and permeate TO increase of approximately 20% over the range of increasing feed TO concentrations. The scatter of data about the trend lines is very large, particularly for flux, and it is quantified by error variances of 9908 for the flux and 124 for the permeate. Despite the large scatter, the general direction of these trend lines agree with expectations, however the strength of the relationships are clearly weak, therefore demonstrating the unique low sensitivity of membrane productivity and permeate quality to feed TO concentration. (Similar results are presented for Site "A" in Section 3.3.3, Figure 3-11.)

Ultrafiltration permeate quality clearly indicates a competitiveness with conventional treatment, however, membrane flux requires attention as it is the prime indicator of process economic feasibility. The results from Site "B" indicate a problem with the control of membrane fouling and therefore maintaining membrane flux rates. The fouling generally appears better controlled at Site "B" than at Site "A," but the fouling is persistent and gradually reduces membrane productivity. As previously noted, the solution to membrane fouling problems can come for several methods; by displacing the foulant present on the membrane surface using membrane cleaning methods, by removing the foulant (either physically or chemically) from the feed stream so as to avoid contact with the membrane surface, and/or by changing the membrane chemistry to resist the troublesome foulant all together. The solution to fouling will likely come from the knowledge of how the UF system is affected by different produced water characteristics, some of these characteristics and effects are discussed below.

FIGURE 4-10

Site "B," HEM-07 Flux and HEM-07 Permeate Concentration of Total Oil Versus Membrane Feed Concentration of Total Oil.



The feed source at Site "B" had some similarities and differences from the feed source at Site "A." The TO concentration was similar at both sites, varying in the range of 100 to 1000 ppm. The TDO concentration were almost an order of magnitude lower at Site "B" than at Site "A," but it is unlikely TDO has any direct effect on flux as virtually all TDO passes through the membrane. TDS concentrations were, at times, an order of magnitude higher at Site "B" than at Site "A." It seems unlikely TDS would play a significant role in flux, as it too passes through the membrane,

Contrary to what we might expect, membrane flux indicated a positive effect to increasing TDS. Normally, increasing the ionic strength (from increasing TDS) in a oil-water solution will destabilise an emulsified oil; causing the oil to coalesce and form free oil. And, it is clear, free oil is a fouling threat for the membranes tested and, from deduction, we would anticipate increased TDS should cause a flux decrease. Figure 4-11 indicates the exact opposite trend, were the HEM-07 flux appears to increase with increasing TDS - note how low the TDS was through the last half of Site "B" tests and the correspondingly low flux levels. This is not the first time this effect has been noted, however, as a similar effect was reported in earlier work on produced water.[1] What may be happening is that the increased presence of ions at the membrane surface makes the membrane more hydrophilic, and therefore passes more water. The behaviour is commonly noted in the low flux of deionised water through a membrane, but not ordinarily observed in waste waters. This relationship will be of particular interest in selecting suitable sites for produced water UF treatment.

The average TSM increased by roughly 3 fold from Stage IV to Stage V, possibly explaining lower flux rates in the final stage of Site "B." The average TSM changed; from 722 mg/L, sd 791, in Stage IV to 2023 mg/L, sd of 2283, in Stage V (calculated from results in Appendix D). Normally a change in TSM will not effect flux, particularly in this low range, but a graph of flux versus TSM clearly indicates a relationship between these two parameters (see Figure 4-12) .

FIGURE 4-11

Site "B," Stage IV and V, HEM-07 Flux and Membrane Feed Concentration of Total Dissolved Solids (TDS) Versus Run Time.

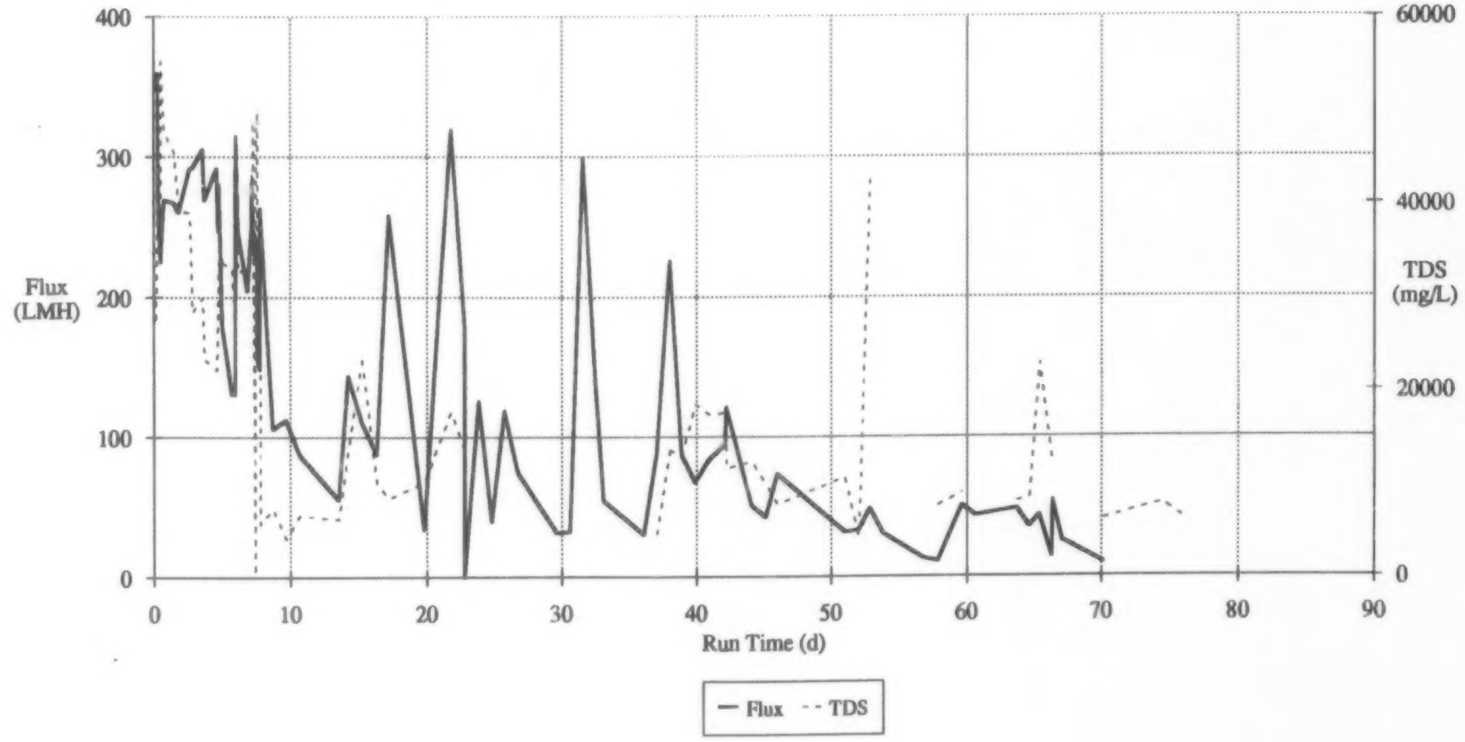
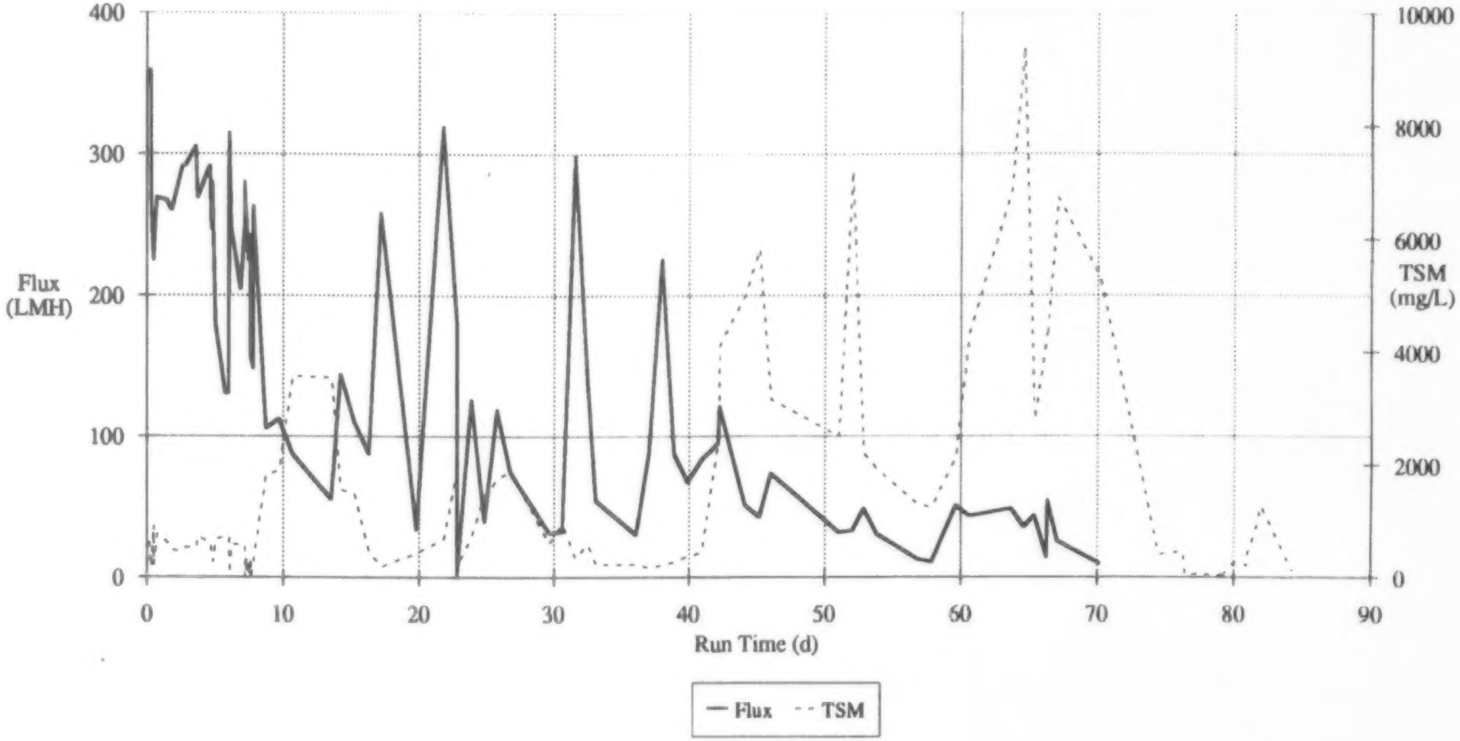


FIGURE 4-12

Site "B," Stage IV and V, HEM-07 Flux and Membrane Feed Concentration of Total Suspended Matter (TSM) Versus Run Time.



The clay noted by operators during Stage V tests was a large fraction of the measured TSM. The presence of clay in tubular ultrafiltration is normally not a big problem; the clay is swept from the membrane surface as a result of in-line turbulence. However, clay is often used as means of coagulating oil (since oil has a strong affinity for clay), and it is speculated that if the oil comes out of emulsion to attach to clay particles, the oil on the clay particle becomes "free" and has a greater affinity for the membrane surface. Once the particle attaches to the membrane surface, it becomes difficult to remove both chemically and physically. To avoid the fouling problem, either the affinity of oil to the clay must be eliminated or the clay must be removed from the system entirely.

Removal of the clay from the feed is likely the easiest solution. The level of prefiltration used in the current tests was a 20μm bag-filter, but it obviously was not tight enough for fine clay particle removal (estimated at 1 μm to 5 μm in diameter). The physical removal of this smaller size of solids would require a pretreatment operation of a filter press, a microfiltration system, or possibly a flocculation settling system. The impact of any of theses additional pretreatment costs to the overall produced water UF treatment costs needs to be assessed. Since the potential improvements in UF performance, as a result of optimal pretreatment, may dramatically improve the economic attractiveness of the process.

Reduction of clay-oil affinity is not as straight forward as particle filtration, but it may be more cost efficient to the overall process. The reduction in clay-oil affinity may be possible with the right chemical addition to the feed source. The adjustment of pH using NaOH during Stage V was done in an attempt to increase oil emulsion stability and thus reduce clay-oil affinity. The results did not demonstrate this reduction however. Samples of pH 9 and non pH adjusted feeds were later analysed for differences and, in brief, there was no appreciable change in the TO, TDS, TSS, or ion scan of the supernatant of either sample, nor was there consistent change in the ion level of each sludge (refer to Appendix E). If oil was removed from the clay, we would expect TSS levels to be lower in the adjusted sample not the same. The best choice for chemical addition may not be NaOH, but other forms of chemical additives may be worth considering in future tests, as this approach to alleviating the clay problem is likely more cost effective.

Finally, membrane cleaning throughout Site "B" testing was not adequate enough to completely rejuvenate fouled membranes. The presence of foulant in the feed stream was more than could be dealt with properly by the cleaner. In most cases, fouling reoccurred sharply after a cleaning and as a result the benefits of the cleaning were not realised for long. The cleanings appeared to be roughly 90% effective on a single cleaning, but persistent foulants gradually reduced the flux. If the most persistent foulants can be removed from the system (e.g. clay), it is likely the 4XMC-3 cleaner will be suitable for this UF application. Otherwise, more aggressive cleaning agents will be needed to remove the foulant layer. More aggressive cleaners would not be compatible with the membrane used in this study, however, possibilities are currently being investigated into the development of a membrane resistant to strong solvents. The strong solvents could be used as a membrane cleaner, and would most certainly attack and displace a clay-oil foulant from a solvent resistant membrane.

5.0 ECONOMIC ASSESSMENT

5.1 Design Basis

Cost estimates were previously prepared for both a conventional and membrane based treatment process treating 1325 L/min (350 USgpm) of produced water effluent from a High Temperature Separator or Free Water Knockout unit.[1] The costs were developed for a conventional treatment process as depicted in Figure 5-1, and for a membrane based system as depicted in Figure 5-2. The membrane cost estimates have been adjusted to incorporate the knowledge gained from the current test work: 1) addition of a Skim Tank (with no chemical addition) prior to the membrane system to remove free oil, 2) increased cleaning frequency from biweekly to weekly and 3) increased cleaning dosage by a factor of four (i.e. 4XMC-3). Costing is based the projected commercial selling price of $270/m^2 for a disposable tubular membrane. A cost breakdown and the design detail of both the conventional and the membrane treatment process are in Appendix H.

5.2 Cost

Table 5-1 summarizes the costs of the two technologies and Figure 5-3 illustrates a cost comparison of the two processes. The annual costs (including 10 year amortization of capital) of the conventional and membrane based treatment is plotted against membrane flux rate. Membrane treatment costs were based on membrane replacements periods of 0.5, 1, 2 and 3 years. From Figure 5-3, membrane flux intercepts conventional treatment costs at 85, 95, 115, and 160 LMH for membrane replacement periods of 3,2,1 and 0.5 years, respectively. Therefore, in order for the membrane treatment process to be more economically attractive than the conventional treatment process, flux rates needed to be greater than the intercept for a projected lifespan.

FIGURE 5-1

Process Flow Schematic for Cost Assessment of Conventional Produced Water Treatment.

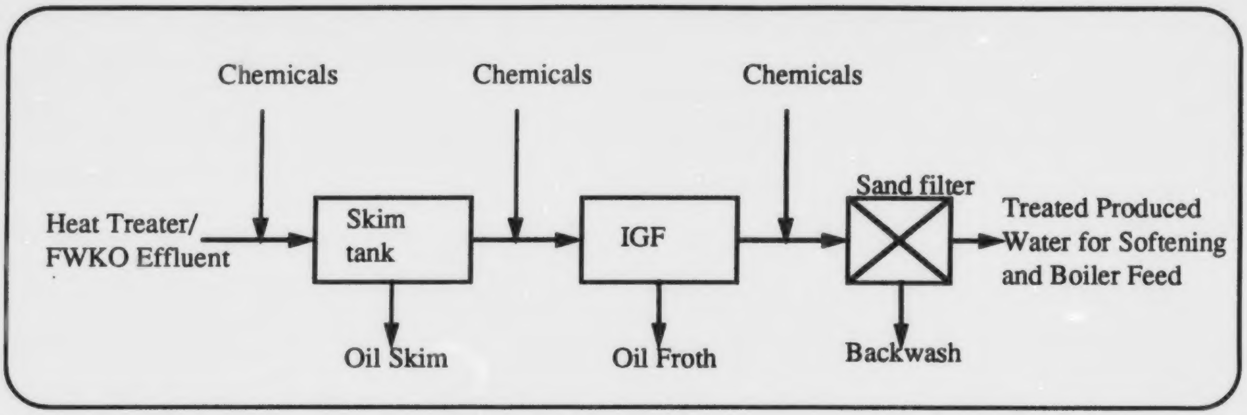

Chemicals
Chemicals
Chemicals
Sand filter
Heat Treater/
FWKO Effluent
Skim
tank
IGF
Treated Produced
Water for Softening
and Boiler Feed
Oil Skim
Oil Froth
Backwash

FIGURE 5-2

Process Flow Schematic for Cost Assessment of Membrane Based Produced Water Treatment.

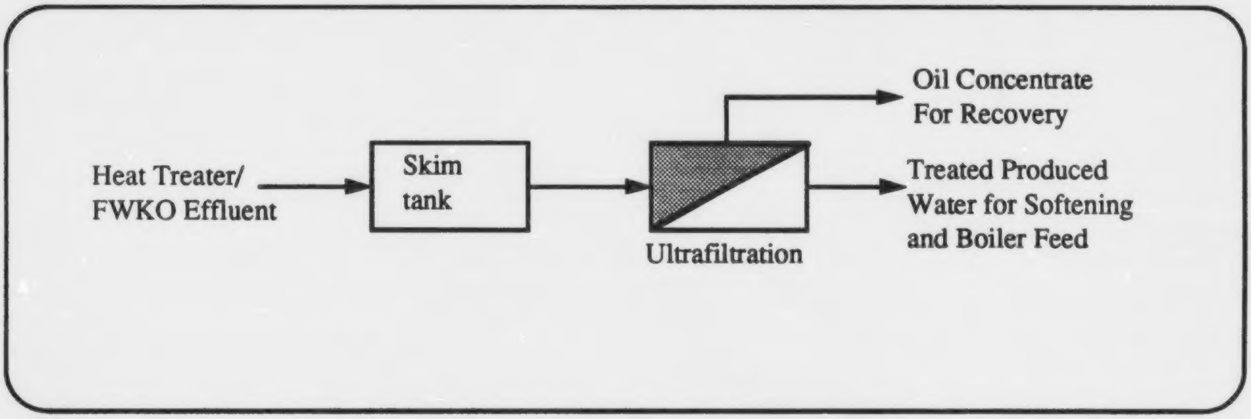

Oil Concentrate
For Recovery
Heat Treater/
FWKO Effluent
Skim
tank
Treated Produced
Water for Softening
and Boiler Feed
Ultrafiltration

FIGURE 5-3

Yearly Costs for Conventional and Membrane Based Produced Water Treatment Processes (10 Year Amortization of Capital), with Membrane Replacement Costs for 0.5, 1, 2, and 3 Years Versus Membrane Flux Rate.

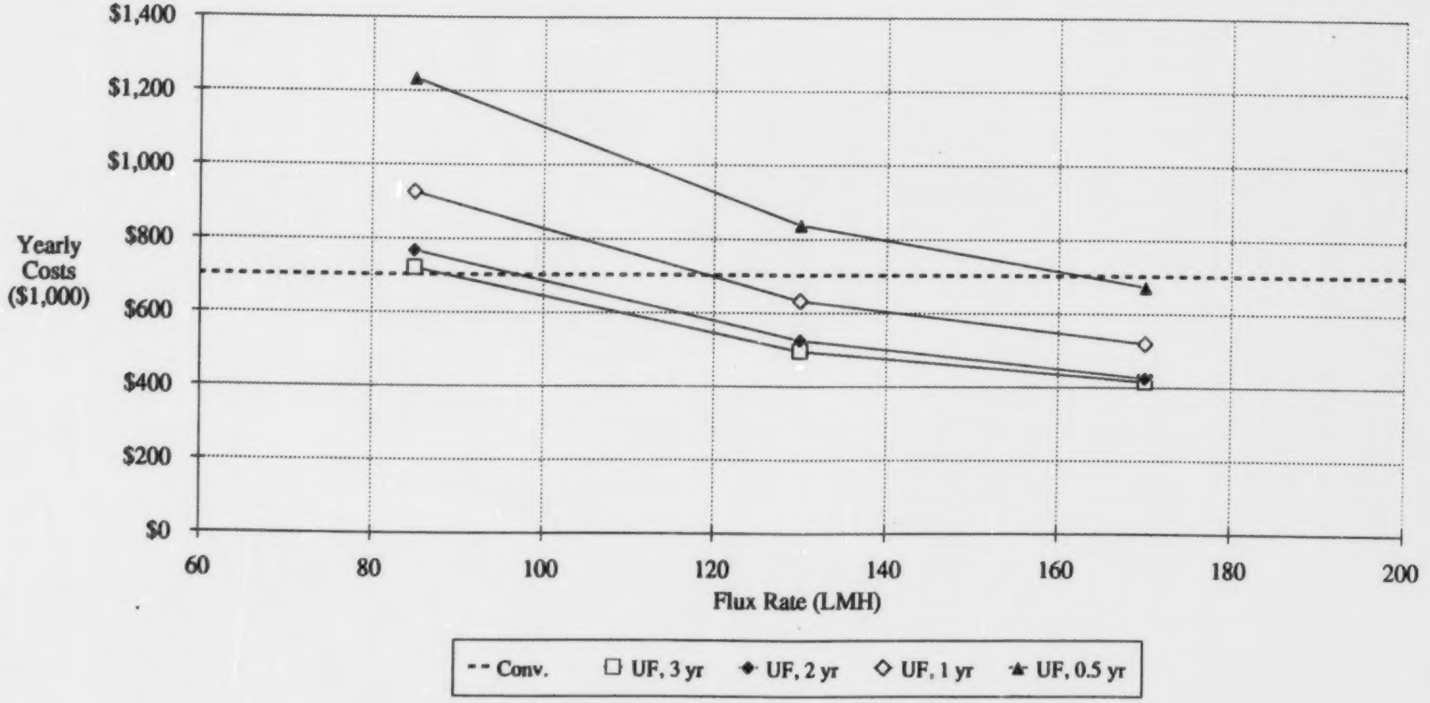


TABLE 5-1

Capital and Operating Costs for Conventional
and Membrane Based Processes for Oil Removal

					3 year span	2 year span	1 year span	0.5 year span
Oil Removal Process	Module Cost	Assumed Flux (LMH)	Capital Cost ($1,000)	Operating Costs* ($1,000/yr.)	Yearly Costs** $1,000)	Yearly Costs** ($1,000)	Yearly Costs** ($1,000)	Yearly Costs** ($1,000)
Conventional	---	---	$1,573	$434	$702	$702	$702	$702
Membrane	$270/m2	170	$1,004	$254	$416	$425	$519	$673
		130	$1,339	$298	$496	$526	$633	$839
		85	$1,884	$447	$720	$768	$926	$1,235

* Example, based on a two year membrane life span.
** Including Capital cost amortized at 11 % interest over 10 years.

5.3 Discussion

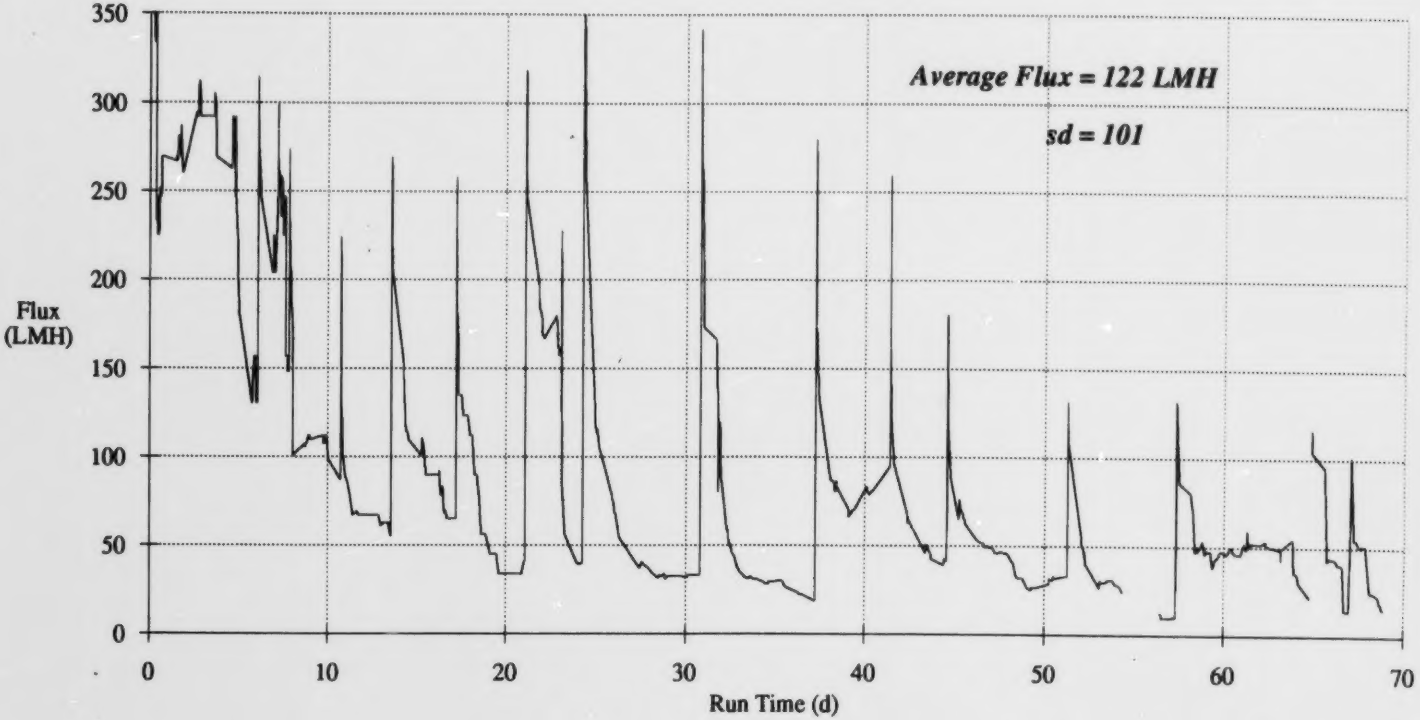
Produced water ultrafiltration indicates potential for cost competitiveness with conventional treatment operations. The flux levels and membrane life spans indicated as cost competitive in Figure 5-3, are well within reach of current membrane filtration technology. However, results reported for the membrane testing at Site "A" and Site "B" demonstrated flux levels that are borderline and often times too low to indicate ultrafiltration is the most economically attractive method of produced water treatment. For example, for a three year membrane life span a flux of approximately 85 LMH is required for ultrafiltration to be comparable with the economics of conventional treatment. If we consider average flux to be the only indicator of long term flux potential, all of the membranes tested, with the exception of two in Stage V, satisfy the 85 LMH target flux. However, all of the membranes indicated a gradual decrease in flux over time and, with few exceptions, the membranes tested for the longest period of time had the lowest final flux rate. Although it is not suggested the absolute final flux rate be used for costing, it does seem logical to only consider the portion of run time near the end of a membrane test.

The HEM-07 membrane underwent the longest experimentation of all of the membranes tested, and a complete flux versus run time is shown in Figure 5-4. Although the calculated average flux rate for the HEM-07 over this period is 122 LMH, the flux near the end of testing is about 50 LMH. The greater than two fold difference between these values clearly reflects the high standard deviation, 101, in flux over time. From Figure 5-3, a flux of 50 LMH for a three year life falls below the conventional treatment cost line. This result suggests the conventional treatment process has greater economic attractiveness than the membrane treatment process. This finding is true but requires qualification, since the membrane performance is extremely dependent on the nature of the feed treated. And, as was discussed earlier (see Section 4.3.3), if clay is present in the produced water feed stream, as it clearly was in Stage V, it will foul the membranes a cause a flux decrease. Therefore, if clay is not present (or present in low concentration) in a produced water, it is quite possible the membrane treatment process would indicate greater economic attractiveness than the conventional treatment process. For situations where clay is present in a produced water stream, either a pretreatment method needs to be developed or a adequate cleaning method is required to efficiently remove the clay.

Membrane life span is also important to the cost assessment of the membrane process, as can be seen in Figure 5-3. Treatments costs escalate quickly as membrane life span shortens. It is ZENON's common experience that a membrane will foul to a baseline flux and then stabilise at that flux for most of the membrane life span. However, none of the membranes tested at Site "A" and Stage "B" had reached a stable flux rate in the test times provided. If feed conditions continued as they were, it is possible the flux for each of the membranes may have decreased to near zero over the long term. For example, the HEM-07 would likely have approached a flux of zero at roughly 0.5 years of run time if fouling conditions were to continued. However, if fouling conditions had been controlled, there is good reason to believe the HEM-07 would last for two to three years or more.

FIGURE 5-4

Site "B," Stages IV and V, Flux Versus Run Time for the HEM-07 Membrane.



In summary, the efficacy of the produced water treatment process is very much dependent on the particular nature of a produced water stream. If conditions of emulsified feed oil with no clay present can be achieved, membrane treatment would likely indicate an economic advantage over the conventional treatment process. For EOR operations were these conditions can not be met, conventional treatment of produced water would appear to be the more cost effective solution. In the mean time, more study is recommended in the area of a special membrane product more tolerable to these adverse conditions (see Section 6.2).

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- Each membrane type (HEM, HST, HSC) demonstrated complete separation of emulsified oil from produced water. In general, the membranes rejected approximately 85% of the total oil (TO) and 20% of the total dissolved oil (TDO). Virtually 100% of total suspended matter (TSM) and 0% of total dissolved solids (TDS) were rejected by the membranes. Typical membrane TO removal for Site "A" and Site "B" is shown in Table 6-1. The quality of ultrafiltration permeate was comparible to, if not better than, conventional produced water treatment. In addition, the quality of membrane separation remained relatively constant throughout testing, despite large changes in feed concentrations. This insensitivity demonstrates the excellent potential for ultrafiltration to dampen EOR treatment system upsets.

TABLE 6-1
Typical Membrane Total Oil Removal at Site "A" and Site "B"

EOR Operation	Membrane Feed (mg/L)	Permeate (mg/L)	TO Removal
Site "A"	2000	100	95%
Site "B"	1000	30	97%

- Flux was dependent on the feed stream characteristics as well as the length of time the membrane processed produced water. In general with regard to feed stream characteristics (only for Site "B"), flux increased as the concentration of TDS increased, decreased as the concentration of TSM increased, and remained stable as the concentration of TO increased. Finally, membrane flux gradually reduced over run time - indicating irreversible fouling was controlling flux performance.

There was no one membrane type that clearly out performed the others in regard to flux. The longest membrane run time was 1694 hours recorded for the HEM-07, and it performed with an average flux of 122 LMH, with a standard deviation of 101. Other membrane types had higher average flux rates, but they were run for shorter periods of time and are not considered as representative of long term flux performance. The average flux is somewhat misleading in respect to long term flux performance, since fouling prevented the membranes from reaching a stable flux level before the end of testing. Flux levels near the end of testing may be a better indicator of long term potential. The flux from the HEM-07 membrane near the end of testing was approximately 50 LMH.

- Membrane fouling could not be completely controlled by membrane cleaning, and as result gradual flux reduction was noted over continued run time. Fouling was primarily linked to the presence of clay (as part of TSM) in the produced water feed stream (more notably at Site "B"). The clay destabilised the oil emulsion by attracting oil micelles to clay surfaces. The sticky clay-oil particles were attracted to the membrane surface and adhered strongly, as illustrated in photos of fouled surfaces. Chemical cleaning with 4XMC-3 was not sufficient to completely break up and remove the combined clay-oil foulant from the membrane surface, although roughly 80 percent flux rejuvenation was possible for any one cleaning. Methods for removing the clay need to be addressed in future work. Other recognised sources of membrane foulants experienced during the testing included extreme free oil (95% oil in water) and injection foam. These sources of fouling could be easily avoided and need to be considered in future testing.
- An economic assessment indicates ultrafiltration requires a flux of 85 LMH to be cost competitive with conventional technology. Based on average flux rates, most of the membranes met this flux criterion. However, long term flux potential is uncertain since none

of the membranes clearly reached a stable flux level before the end of testing. An approximate projection of results would suggest fluxes of no greater than 50 LMH could be achieved over the long term at either of the two sites tested. This projection indicates current membrane technology would not be competitive with conventional technology at EOR sites where clay is problem, such as the two sites tested. More study is needed in the area of produced water pretreatment for clay (TSM) removal and/or new membrane technology more resistant to the presence of clay and clay-oil fouling. Where clay is not present (or present in low concentrations) in produced water, the current level of membrane technology indicates good economic competitiveness with conventional technology.

6.2 Recommendations

The results of the reported study indicate the current level of ultrafiltration technology has limitations on the kinds of produced waters it can treat cost effectively. If ideal feed conditions can be achieved (i.e. emulsified oil with no clay), long term flux rates will likely not be much higher than 150 LMH using current low temperature tubular membrane technology. Although this flux is higher than the 85 LMH required to be cost competitive with conventional technology, it may not be high enough to ensure the attractiveness of membrane technology over conventional technology. However, the potential for ultrafiltration can be greatly heightened by improving membrane and module design. It is recommended more research focus be placed on the design of a polymeric membrane resistant to high temperature and aggressive solvents. These two features would enable membrane treatment of produced water prior to cooling at the Skim Tank therefore improving the economics through higher membrane fluxes (potential a three to four fold flux increase at the higher temperature), as well as lower energy requirements at steam boilers. A solvent resistant feature would allow aggressive solvents to be used as cleaner to dissolve any free oil fouling the membrane. In addition, the new membrane product should withstand back flushing. This feature would be useful at EOR sites where clay is present in the feed stream, since frequent back flushing would displace clay foulant from the membrane surface. Finally, the new membrane product could be configured in fibres ("outside-in" permeate path) rather than in tubes. This configuration would increase the membrane area to unit volume ratio and reduce membrane module costs. All of these attributes in a new module design would strengthen the economic driving force from conventional treatment to membrane produced water treatment. Preliminary screening studies by ZENON indicate this module design is well within reach using current knowledge and technology.

7.0 REFERENCES

1) ZENON Environmental Inc. (1987) "Membrane Processing of Oil Field Produced Water for Enhanced Oil Recovery (EOR) Steam Generation," Final Report Prepared for Energy Mines and Resources, CANMET/ERL, Contract No. 03SQ.23440-5-9111.

2) AOSTRA, "Technical Handbook on Oil Sands, Bitumens and Heavy Oils," Edited by L.G. Loren and C. Hsi, AOSTRA, 1989, Chapter 9.

GLOSSARY

Batch	The volume of liquid in the Process Tank prior to volume reduction.
Cleaning	Removing foulants from the membrane surface.
Concentrate	Liquid not passed through the membrane, retentate.
Flux	Volume rate of permeate per unit volume of membrane area available; expressed in units of L/m2/h , or LMH. Divide by 240 for m3/m2/d or divide by 1.7 for USg/ft2/d (USGFD).
Foulant	Substances in a feed stream attracted to the membrane surface and cause reductions in flux.
Fouling	The act of foulant adhering to the membrane surface.
Membrane	Porous polymeric material coating a highly porous support.
Membrane Feed	Liquid passed across the membrane surface at any given operating time.
Module	Housing for membrane tubes. May also refer to the membrane tubes within the module.
MWCO	The nominal thereshold molecular weight of compounds defining what the membrane will reject.
Permeate	Liquid passing through the membrane, filtrate.
Pressure,Inlet	Pressure measured at the entrance to the module.
Pressure,Outlet	Pressure measured at the exit to the module.
Volume Reduction	Percentage of Initial feed generated as treated permeate.

ABBREVIATIONS

FBM	Feed and Bleed Mode, see Appendix E
HEM	ZENON membrane type
HSC	ZENON membrane type
HST	ZENON membrane type
IGF	Induced Gas Flotation
LMH	Units to describe Flux, representing L/m2/h
MBM	Modified Batch Mode, see Appendix E
MC-3	ZENON membrane cleaner
4XMC-3	ZENON membrane cleaner, quadruple the strength MC-3
MP-1	ZENON membrane perservative
MWCO	Molecular Weight Cut Off (for a membrane type)
RBM	Regular Batch Mode, see Appendix E
TDO	Total Dissolved Oil, mg/L
TDS	Total Dissolved Solids, mg/L
TO	Total Oil, mg/L
TSM	Total Suspended Matter (including TSS and hydrocarbon solids), mg/L
TSS	Total Suspended Solids (excluding hydrocarbon solids), mg/L
UF	Ultrafiltration
VR	Volume Reduction
sd	Standard Deviation

Volume

2

ZENON

ULTRAFILTRATION FIELD PILOT TESTING
FOR THE
TREATMENT OF PRODUCED WATER

Volume II

APPENDICES

Final Report

By

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Work on this project was conducted under the auspices of the Department of Energy, Mines and Resources.

DSS File Number: 03SQ.23440-7-9165

DSS Contract Number: 23440-7-9165/01-SQ

EMR Scientific Authority: Brian Farnand

289 pp

MICROMEDIA

File No. CO874073

June 28, 1990

APPENDIX A

Site "A" - Operating Data

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 18-Aug-88

Mode: RBM
Operator: JRI

Run Number: 1

Elapsed Time (min)	Temp. (°C)	HEM - 01			HST - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	70.0	68.1	258.6	337.0	68.1	258.6	404.4	0.0
30.0	70.0	68.1	258.6	269.6	68.1	258.6	247.1	37.9
105.0	69.6	68.1	258.6	202.2	68.1	258.6	195.4	49.4
120.0	70.4	68.1	258.6	202.2	68.1	258.6	202.2	70.1
143.0	71.3	68.1	258.6	202.2	68.1	258.6	202.2	82.2
160.0	72.7	68.1	258.6	202.2	68.1	258.6	190.9	94.0
170.0	72.7	68.1	258.6	179.7	68.1	258.6	177.5	94.3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 18-Aug-88

Mode: RBM
Operator: JRI

Run Number: 2

Elapsed Time (min)	Temp. (°C)	HEM - 01			HST - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	68.7	68.1	258.6	157.2	68.1	258.6	146.0	0.0
15.0	71.3	68.1	258.6	157.2	68.1	258.6	155.0	19.5
30.0	73.5	68.1	258.6	157.2	68.1	258.6	155.0	35.6
60.0	72.7	68.1	258.6	134.8	68.1	258.6	155.0	69.5
83.0	72.2	68.1	258.6	130.3	68.1	258.6	123.6	74.7
113.0	73.5	68.1	258.6	123.6	68.1	258.6	112.3	93.7

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 19-Aug-88

Mode: RBM
Operator: JRI

Run Number: 3

Elapsed Time (min)	Temp. (°C)	HEM - 01			HST - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	70.9	68.1	258.6	179.7	68.1	258.6	157.2	0.0
20.0	70.9	68.1	258.6	157.2	68.1	258.6	123.6	20.7
30.0	70.9	68.1	258.6	146.0	68.1	258.6	112.3	29.9
60.0	71.1	68.1	258.6	134.8	68.1	258.6	89.9	59.8
94.0	71.1	68.1	258.6	112.3	68.1	258.6	67.4	82.8
118.0	70.9	68.1	258.6	101.1	68.1	258.6	49.4	93.7
158.0	71.1	68.1	258.6	78.6	68.1	258.6	44.9	93.7

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 19-Aug-88

Mode: Cleaning
Operator: JRI

Run Number: 3C

Elapsed Time (min)	Temp. (°C)	HEM - 01			HST - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	31.0	68.1	258.6	213.4	68.1	258.6	74.1	0.0
20.0	31.0	68.1	258.6	202.2	68.1	258.6	78.6	0.0
30.0	31.0	68.1	258.6	199.9	68.1	258.6	78.6	0.0
60.0	31.0	68.1	258.6	190.9	68.1	258.6	78.6	0.0
94.0	30.6	68.1	258.6	182.0	68.1	258.6	78.6	0.0

Cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 22-Aug-88

Mode: RBM
Operator: PCF

Run
Number: 4

Elapsed Time (min)	Temp. (°C)	HEM - 01			HST - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	69.0	70.0	247.5	134.7	70.0	250.0	67.1	0.0
15.0	69.0	70.0	252.5	127.6	70.0	255.0	58.2	10.3
30.0	69.0	69.0	250.0	114.5	69.0	252.5	49.3	20.1
70.0	69.0	70.0	247.5	108.0	70.0	250.0	45.1	43.1
100.0	69.5	70.0	248.0	100.9	70.0	250.0	<45.1	52.9
130.0	68.5	70.0	250.0	67.1	70.0	252.5	<45.1	66.7
160.0	70.0	70.0	250.0	67.1	70.0	252.5	<45.1	82.8
190.0	70.0	70.0	247.5	62.9	70.0	252.5	<45.1	92.5
196.0	70.0	71.0	242.5	62.9	70.0	250.0	<45.1	93.1
230.0	70.0	70.0	247.5	49.3	71.0	252.5	<45.1	93.3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 23-Aug-88

Mode: RBM
Operator: PCF

Run Number: 5

Elapsed Time (min)	Temp. (°C)	HEM - 01			HST - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	67.0	73.0	250.0	84.9	71.0	257.5	<45.1	0.0
15.0	70.0	73.0	250.0	84.9	71.0	257.5	<45.1	7.5
30.0	70.0	73.0	248.5	84.9	71.0	258.5	<45.1	13.8
60.0	70.0	73.0	247.5	78.3	71.0	257.5	<45.1	24.7
90.0	70.0	73.0	247.5	78.3	71.0	257.5	<45.1	35.6
120.0	70.0	73.0	247.5	74.2	71.0	255.0	<45.1	46.6
173.0	70.0	73.0	247.5	74.2	71.0	252.5	<45.1	68.4
250.0	70.0	73.0	245.0	69.4	71.0	250.0	<45.1	93.1
290.0	70.0	72.0	242.5	67.1	69.0	250.0	<45.1	93.9

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 24-Aug-88

Mode: Cleaning
Operator: PCF

Run
Number: 5C1

Elapsed Time (min)	Temp. (°C)	HEM - 01			HST - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	46.0	70.0	248.5	56.4	70.0	248.5	<45.1	0.0
23.0	73.0	70.0	250.0	134.7	70.0	250.0	49.3	0.0
30.0	76.0	70.0	250.0	134.7	70.0	252.5	67.7	0.0
45.0	75.0	71.0	251.5	146.0	71.0	254.0	67.7	0.0
68.0	75.0	71.0	252.5	157.3	71.0	253.5	69.4	0.0
90.0	75.0	71.0	253.0	157.3	71.0	253.5	69.4	0.0

Cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 24-Aug-88

Mode: Cleaning
Operator: PCF

Run Number: 5C2

Elapsed Time (min)	Temp. (°C)	HEM - 01			HST - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	44.0	71.0	254.0	123.4	71.0	254.0	62.3	0.0
15.0	59.0	71.0	253.5	146.0	71.0	253.5	67.1	66.7
37.0	75.0	71.0	254.5	177.5	71.0	256.0	83.1	66.7
75.0	75.0	71.0	253.0	175.1	72.0	255.0	78.3	66.7
85.0	80.0	71.0	253.0	179.8	71.0	255.0	80.7	66.7
115.0	79.0	70.0	252.5	101.1	71.0	255.0	80.7	66.7
165.0	79.0	71.0	254.0	78.6	71.0	256.0	78.3	66.7

Cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 26-Aug-88

Mode: RBM
Operator: PCF

Run Number: 6

Elapsed Time (min)	Temp. (°C)	HEM - 01			HSC - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	66.0	68.0	256.0	224.9	81.0	254.5	314.0	0.0
15.0	74.0	68.0	254.5	159.1	71.0	255.0	246.9	0.6
20.0	74.0	65.0	256.0	138.9	71.0	258.5	201.8	3.4
30.0	75.0	67.0	255.5	141.3	71.0	258.0	201.8	9.8
61.0	75.0	65.0	252.5	121.1	71.0	255.0	181.6	47.1
85.0	75.0	65.0	252.0	107.4	71.0	252.0	156.7	83.3
100.0	75.0	67.0	252.5	112.2	71.0	252.5	161.4	93.1
150.0	75.0	70.0	254.0	93.8	71.0	254.0	156.7	94.3

Cleaned for 1.5 hours with MC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"
Date: 29-Aug-88

Mode: RBM
Operator: PCF

Run
Number: 7

Elapsed Time (min)	Temp. (°C)	HEM - 01			HSC - 01			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	60.0	68.0	251.0	190.5	80.0	251.0	314.0	0.0
12.0	79.0	68.0	254.0	156.7	76.0	254.5	112.2	6.9
30.0	75.0	69.0	254.0	103.3	76.0	256.5	58.2	24.1
75.0	74.0	71.0	252.5	67.1	75.0	255.0	<45.1	44.3
105.0	75.0	71.0	252.5	67.1	75.0	254.0	<45.1	51.1
130.0	75.0	72.0	252.5	62.3	75.0	252.5	<45.1	62.1
210.0	75.0	71.0	253.0	58.2	75.0	253.0	<45.1	62.6
270.0	75.0	71.0	252.5	53.4	75.0	252.5	<45.1	74.7

*Inaccurate values, see report Section 2.3.2

File Nó. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"
Date: 29-Aug-88

Mode: Cleaning
Operator: PCF

Run Number: 7C

Elapsed Time (min)	Temp. (°C)	HEM - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	47.0	71.0	250.0	44.9	-	-	-	0.0
15.0	64.0	71.0	250.0	69.4	-	-	-	0.0
30.0	75.0	71.0	251.5	89.6	-	-	-	0.0
45.0	75.0	71.0	252.0	89.6	-	-	-	0.0

Cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"	Mode: RBM	Run
Date: 30-Aug-88	Operator: PCF	Number: 8

Elapsed Time (min)	Temp. (°C)	HEM - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	65.0	68.0	253.5	152.5	-	-	-	0.0
15.0	75.0	68.0	253.5	112.8	-	-	-	5.2
30.0	75.0	68.0	253.5	94.4	-	-	-	10.3
60.0	75.0	69.0	254.0	78.3	-	-	-	18.4
120.0	74.0	69.0	254.0	67.1	-	-	-	35.6
200.0	74.0	69.0	254.0	62.9	-	-	-	54.6
260.0	75.0	69.0	253.0	58.2	-	-	-	66.1
320.0	75.0	69.0	255.0	54.0	-	-	-	75.3
400.0	76.0	69.0	254.5	49.3	-	-	-	88.5
428.0	75.0	69.0	254.5	46.9	-	-	-	93.1

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"
Date: 31-Aug-88

Mode: Cleaning
Operator: PCF

Run Number: 8C1

Elapsed Time (min)	Temp. (°C)	HEM - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	56.0	68.0	251.5	54.0	-	-	-	0.0
30.0	65.0	68.0	251.5	65.3	-	-	-	0.0
60.0	76.0	69.0	252.0	78.3	-	-	-	0.0
90.0	75.0	69.0	253.5	78.3	-	-	-	0.0
112.0	75.0	69.0	253.0	71.8	-	-	-	0.0

Cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"
Date: 31-Aug-88

Mode: Cleaning
Operator: PCF

Run Number: 8C2

Elapsed Time (min)	Temp. (°C)	HEM - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	45.0	67.0	251.5	71.8	-	-	-	0.0
30.0	66.0	68.0	253.0	89.6	-	-	-	0.0
45.0	71.0	68.0	252.5	89.6	-	-	-	0.0
71.0	76.0	68.0	252.5	89.6	-	-	-	0.0
135.0	75.0	68.0	253.0	87.8	-	-	-	0.0

Cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"
Date: 31-Aug-88

Mode: Cleaning
Operator: PCF

Run
Number: 8C3

Elapsed Time (min)	Temp. (°C)	HEM - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	53.0	67.0	253.5	71.8	-	-	-	0.0
15.0	71.0	67.0	254.0	89.6	-	-	-	0.0

Cleaned with MC-3, followed by overnight soaking in cleaner

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"
Date: 1-Sep-88

Mode: Cleaning
Operator: PCF

Run Number: 8C3 con't

Elapsed Time (min)	Temp. (°C)	HEM - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	58.0	65.0	254.0	87.8	-	-	-	0.0
15.0	74.0	66.0	250.0	89.6	-	-	-	0.0
26.0	75.0	66.0	253.5	89.6	-	-	-	0.0

Recirculated MC-3 cleaner from previous day.

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"
Date: 1-Sep-88

Mode: Cleaning
Operator: PCF

Run
Number: 8C4

Elapsed Time (min)	Temp. (°C)	HEM - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	48.0	66.0	251.5	80.1	-	-	-	0.0
15.0	57.0	66.0	252.0	87.8	-	-	-	0.0
30.0	75.0	67.0	253.0	93.8	-	-	-	0.0
61.0	74.0	67.0	253.5	89.6	-	-	-	0.0
79.0	79.0	67.0	254.0	93.8	-	-	-	0.0
98.0	78.0	67.0	253.5	92.6	-	-	-	0.0

Cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"
Date: 1-Sep-88

Mode: Cleaning
Operator: PCF

Run Number: 8C5

Elapsed Time (min)	Temp. (°C)	HEM-01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	50.0	63.0	251.5	83.1	-	-	-	0.0
15.0	7378.0	66.0	241.5	89.6	-	-	-	69.0
33.0	78.0	66.0	241.5	89.6	-	-	-	69.0
50.0	78.0	67.0	254.0	96.1	-	-	-	69.0
75.0	79.0	67.0	254.0	96.1	-	-	-	69.0
108.0	74.0	66.0	253.0	96.1	-	-	-	69.0

Cleaned with MC-3, followed by overnight soaking with fresh cleaner.

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site "A"
Date: 2-Sep-88

Mode: RBM
Operator: PCF

Run
Number: 9

Elapsed Time (min)	Temp. (°C)	HEM - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	73.0	62.0	254.0	157.3	-	-	-	0.0
15.0	74.0	63.0	254.0	87.8	-	-	-	5.7
35.0	75.0	63.0	253.5	56.4	-	-	-	9.8
55.0	75.0	63.0	253.5	45.1	-	-	-	13.2

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 6-Sep-88

Mode: RBM
Operator: PCF

Run Number: 10

Elapsed Time (min)	Temp. (°C)	HEM - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	72.0	67.0	254.0	93.8	-	-	-	0.0
15.0	75.0	67.0	253.5	71.8	-	-	-	4.0
31.0	75.0	67.0	254.0	67.7	-	-	-	8.6
59.0	75.0	66.0	253.5	58.2	-	-	-	13.8
85.0	75.0	66.0	254.0	54.0	-	-	-	16.7
144.0	75.0	66.0	254.0	49.3	-	-	-	28.7
160.0	75.0	66.0	254.0	45.1	-	-	-	32.2

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 12-Sep-88

Mode: RBM
Operator: PCF

Run Number: 11

Elapsed Time (min)	Temp. (°C)	HST - 01			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	65.0	63.0	257.5	246.9	-	-	-	0.0
32.0	67.0	66.0	256.5	139.5	-	-	-	20.7
46.0	75.0	66.0	256.0	139.5	-	-	-	27.6
73.0	74.0	66.0	256.5	116.3	-	-	-	42.5
95.0	75.0	66.0	256.0	112.2	-	-	-	51.7
120.0	75.0	66.0	256.5	108.0	-	-	-	60.9
158.0	75.0	66.0	255.5	89.6	-	-	-	75.9
180.0	75.0	66.0	256.0	88.4	-	-	-	81.0
221.0	76.0	66.0	255.0	71.8	-	-	-	93.1

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 15-Sep-88

Mode: RBM
Operator: PCF

Run Number: 12

Elapsed Time (min)	Temp. (°C)	HEM - 02			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	71.0	63.0	254.0	471.8	-	-	-	0.0
15.0	75.0	63.0	254.0	337.1	-	-	-	24.1
30.0	75.0	63.0	252.5	299.7	-	-	-	41.4
67.0	75.0	63.0	254.0	269.4	-	-	-	75.9
90.0	75.0	63.0	254.0	267.7	-	-	-	93.1

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 15-Sep-88

Mode: Cleaning
Operator: PCF

Run Number: 12-C1

Elapsed Time (min)	Temp. (°C)	HEM - 02			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	70.0	63.0	253.0	280.7	-	-	-	0.0
5.0	75.0	63.0	254.0	292.0	-	-	-	70.1

Cleaned with MC-3, and soaked in cleaner overnight.

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 16-Sep-88

Mode: Cleaning
Operator: PCF

Run Number: 12-C2

Elapsed Time (min)	Temp. (°C)	HEM - 02			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	65.0	63.0	252.5	312.2	-	-	-	0.0
15.0	70.0	63.0	252.0	309.8	-	-	-	67.8
31.0	75.0	63.0	253.0	292.0	-	-	-	67.8

Cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 16-Sep-88

Mode: RBM
Operator: PCF

Run Number: 13

Elapsed Time (min)	Temp. (°C)	HEM - 02			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	68.0	63.0	253.5	406.0	-	-	-	0.0
15.0	75.0	63.0	254.0	325.2	-	-	-	19.5
29.0	75.0	63.0	253.5	296.8	-	-	-	36.8
55.0	74.0	63.0	252.5	283.1	-	-	-	63.2
81.0	76.0	60.0	253.5	269.4	-	-	-	85.1
89.0	75.0	62.0						

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 16-Sep-88

Mode: Cleaning
Operator: PCF

Run Number: 13-C1

Elapsed Time (min)	Temp. (°C)	HEM - 02			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	55.0	66.0	254.0	235.6	-	-	-	0.0
15.0	64.0	66.0	254.0	246.9	-	-	-	69.0
30.0	75.0	66.0	254.5	253.4	-	-	-	69.0
60.0	74.0	67.0	254.5	236.2	-	-	-	69.0

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 19-Sep-88

Mode: RBM
Operator: JRI

Run
Number: 14

Elapsed Time (min)	Temp. (°C)	HEM-02			HST-02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	75.0	62.0	260.0	292.0	61.0	268.5	>562	0.0
15.0	75.0	62.0	260.0	269.4	61.0	268.5	>562	85.1
30.0	75.0	62.0	260.0	269.4	61.0	268.5	561.5	85.1
60.0	75.0	62.0	260.0	269.4	61.0	260.0	561.5	85.1
105.0	75.0	62.0	260.0	269.4	61.0	260.0	541.3	85.1

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 19-Sep-88

Mode: RBM
Operator: JRI

Run Number: 15

Elapsed Time (min)	Temp. (°C)	HEM-02			HST-02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	74.0	63.0	260.0	292.0	61.0	262.5	572.7	0.0
5.0	75.0	63.0	260.0	267.1	61.0	262.5	538.9	11.5
10.0	75.0	63.0	260.0	258.2	61.0	262.5	516.9	29.3
15.0	75.0	63.0	260.0	255.2	61.0	262.5	505.7	43.1
20.0	75.0	63.0	260.0	252.8	61.0	262.5	494.4	57.5
25.0	75.0	63.0	260.0	246.9	61.0	262.5	485.5	71.3
30.0	75.0	63.0	260.0	258.2	61.0	262.5	494.4	83.3
34.0	75.0	63.0	260.0	251.6	61.0	262.5	492.0	94.3
45.0	75.0	61.0	260.0	246.9	60.0	262.5	471.8	94.3
60.0	75.0	63.0	260.0	246.9	61.0	262.5	464.7	94.3
90.0	75.0	63.0	260.0	258.2	61.0	262.5	460.6	94.3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 19-Sep-88

Mode: RBM
Operator: JRI

Run Number: 16

Elapsed Time (min)	Temp. (°C)	HEM-02 Flow Rate (L/min)*	HEM-02 Average Pressure (kPa)	HEM-02 Flux Rate (LMH)	HST-02 Flow Rate (L/min)*	HST-02 Average Pressure (kPa)	HST-02 Flux Rate (LMH)	% Volume Reduction
0.0	76.0	63.0	260.0	289.6	60.0	262.5	538.9	0.0
5.0	74.0	63.0	260.0	260.5	60.0	262.5	476.0	31.6
10.0	74.0	63.0	260.0	249.3	60.0	262.5	471.8	45.4
15.0	74.0	63.0	260.0	249.3	60.0	262.5	460.6	59.2
20.0	75.0	63.0	260.0	249.3	60.0	262.5	449.3	72.4
25.0	75.0	63.0	260.0	249.3	60.0	262.5	438.0	85.1
29.0	76.0	63.0	260.0	249.3	60.0	262.5	427.3	94.8
35.0	76.0	63.0	260.0	249.3	60.0	262.5	427.3	94.8

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 20-Sep-88

Mode: Cleaning
Operator: JRI

Run Number: 16-C1

Elapsed Time (min)	Temp. (°C)	HEM-02			HST-02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	60.0	63.0	260.0	224.3	63.0	260.0	361.4	0.0
15.0	72.0	63.0	260.0	245.1	63.0	260.0	359.7	67.8
30.0	73.0	63.0	260.0	246.9	63.0	260.0	350.8	67.8
60.0	74.0	63.0	260.0	246.9	63.0	260.0	350.8	67.8

Cleaned with MC-3, and soaked overnight in cleaner

*Inaccurate values, see report Section 2.3.2

File No: C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 20-Sep-88

Mode: RBM
Operator: JRI

Run Number: 17

Elapsed Time (min)	Temp. (°C)	HEM-02			HST-02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	70.0	60.0	260.0	314.6	63.0	260.0	507.4	0.0
5.0	72.0	60.0	260.0	280.7	63.0	260.0	471.8	13.2
10.0	74.0	60.0	260.0	267.1	63.0	260.0	462.9	27.0
15.0	74.0	60.0	260.0	267.1	63.0	260.0	449.3	40.2
20.0	74.0	61.0	260.0	258.2	63.0	260.0	438.0	52.9
25.0	75.0	61.0	260.0	254.0	63.0	260.0	408.9	65.5
30.0	75.0	59.0	260.0	249.3	63.0	260.0	417.8	76.4
35.0	75.0	59.0	260.0	224.3	63.0	260.0	361.4	86.8
39.0	75.0	59.0	260.0	204.2	60.0	260.0	348.4	94.3
45.0	75.0	59.0	260.0	179.2	59.0	260.0	303.3	94.3
60.0	75.0	59.0	260.0	157.3	59.0	260.0	258.2	94.3
90.0	75.0	59.0	260.0	154.9	59.0	260.0	245.1	94.3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 20-Sep-88

Mode: Cleaning
Operator: JRI

Run Number: 17-C1

Elapsed Time (min)	Temp. (°C)	HEM-02			HST-02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	40.0	62.0	260.0	179.2	61.0	260.0	246.9	0.0

Soaked in MC-3 cleaner overnight

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 21-Sep-88

Mode: Cleaning
Operator: JRI

Run Number: 17-C2

Elapsed Time (min)	Temp. (°C)	HEM-02			HST-02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	72.0	61.0	260.0	258.2	64.0	260.0	370.9	0.0
15.0	78.0	61.0	260.0	260.5	64.0	260.0	350.2	0.0
30.0	80.0	61.0	260.0	269.4	64.0	260.0	350.2	0.0
45.0	80.0	61.0	260.0	269.4	64.0	260.0	348.4	0.0
60.0	80.0	61.0	260.0	269.4	64.0	260.0	348.4	0.0

Flushed and cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 23-Sep-88

Mode: RBM
Operator: JRI

Run Number: **18**

Elapsed Time (min)	Temp. (°C)	HEM - 02			HST - 02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0	72	60	260	246.9	45	260	303.28	0.0
5	75	60	260	94.4	50	260	112.17	1.1
10	78	60	260	65.3	50	260	56.38	4.0
15	78	60	260	45.1	50	260	45.11	6.3
20	76	60	260	44.5	50	260	22.55	7.5
25	76	60	260	33.8	50	260	22.55	8.4
30	75	60	260	26.7	45	260	17.81	9.8

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 23-Sep-88

Mode: Cleaning
Operator: JRI

Run Number: 18-C1

Elapsed Time (min)	Temp. (°C)	HEM-02			HST-02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0	74	61	260	29.1	61	260	22.49	0.0
15	76	61	260	40.4	61	260	22.49	67.8
30	78	61	257.5	45.1	60	257.5	39.17	63.2
90	78	61	260	45.1	60	260	45.11	63.2

Cleaned with MC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 26-Sep-88

Mode: RBM
Operator: JRI

Run
Number: 19

Elapsed Time (min)	Temp. (°C)	HEM-02			HST-02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0	51	59	253.5	44.5	61	253.5	44.51	0.0
31	57	61	253.5	33.2	65	254	24.33	6.9
54	75	61	253.5	<44.51	65	254	<44.51	9.8
93	75	61	253.5	<44.51	65	254	<44.51	14.4
110	75	61	253.5	14.8	65	254	16.62	14.4

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 27-Sep-88

Mode: Cleaning
Operator: JRI

Run Number: 19-C1

Elapsed Time (min)	Temp. (°C)	HEM-02			HST-02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0	42	57	253.5	<42	59	253.50	<42	0
19	69	57	253.5	<42	59	253.50	<42	85
26	75	57	253.5	42.7	59	253.50	47.48	85
104	75	57	252.5	<42	59	252.50	<42	85
153	75	57	252.5	<42	59	252.50	>150	85
195	75	57	253.5	<42	-	-	-	85

Cleaned with 4XMC-3 and 5% IPA

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 30-Sep-88

Mode: RBM
Operator: PCF

Run
Number: 20

Elapsed		HST-03				-		% Volume
Time (min)	Temp. (°C)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				Reduction
0.0	55.0	55.0	254.0	314.6	-	-	-	0.0
15.0	58.0	55.0	256.0	246.9	-	-	-	20.7
30.0	74.0	55.0	253.5	292.0	-	-	-	35.6
53.0	75.0	55.0	253.5	224.3	-	-	-	56.9
74.0	75.0	55.0	253.0	201.8	-	-	-	73.6
98.0	75.0	55.0	253.5	192.9	-	-	-	90.8

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 30-Sep-88

Mode: RBM
Operator: PCF

Run Number: 21

Elapsed Time (min)	Temp. (°C)	HST-03				-		% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				
0.0	64.0	52.0	253.0	246.9	-	-	-	0.0
15.0	76.0	54.0	253.5	244.5	-	-	-	60.9
34.0	74.0	54.0	253.5	201.8	-	-	-	85.1
60.0	75.0	54.0	253.5	184.0	-	-	-	85.1
120.0	74.0	54.0	253.5	156.7	-	-	-	85.1
132.0	74.0	54.0	253.5	156.7	-	-	-	85.1

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 30-Sep-88

Mode: RBM
Operator: PCF

Run Number: 21-C1

Elapsed		HST-03				-		% Volume
Time (min)	Temp. (°C)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				Reduction
0.0	45.0	54.0	253.0	201.8	-	-	-	0.0
15.0	67.0	54.0	252.5	224.9	-	-	-	69.0
39.0	74.0	55.0	254.0	258.2	-	-	-	69.0
15.0	75.0	63.0	260.0	255.2	-	-	-	43.1
20.0	75.0	63.0	260.0	252.8	-	-	-	57.5
25.0	75.0	63.0	260.0	246.9	-	-	-	71.3
30.0	75.0	63.0	260.0	258.2	-	-	-	83.3
34.0	75.0	63.0	260.0	251.6	-	-	-	94.3
45.0	75.0	61.0	260.0	246.9	-	-	-	94.3
60.0	75.0	63.0	260.0	246.9	-	-	-	94.3
90.0	75.0	63.0	260.0	258.2	-	-	-	94.3

Cleaned with 4XMC-3 and 5% IPA

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 3-Oct-88

Mode: RBM
Operator: PCF

Run
Number: 22

Elapsed Time (min)	Temp. (°C)	HST-03				-		% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				
0.0	57.0	50.0	258.5	449.3	-	-	-	0.0
15.0	72.0	51.0	254.0	269.4	-	-	-	20.7
29.0	75.0	52.0	255.0	130.0	-	-	-	29.3
57.0	75.0	52.0	255.0	71.8	-	-	-	39.1
91.0	75.0	52.0	253.5	56.4	-	-	-	46.6
124.0	75.0	52.0	256.0	46.9	-	-	-	51.7
174.0	75.0	55.0	263.5	-	-	-	-	54.0
201.0	75.0	57.0	253.5	-	-	-	-	56.3
275.0	75.0	57.0	255.5	-	-	-	-	60.3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 3-Oct-88

Mode: Cleaning
Operator: PCF

Run Number: 22-C1

Elapsed Time (min)	Temp. (°C)	HST-03			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				
0.0	42.0	52.0	256.0	44.5	-	-	-	0.0
15.0	64.0	52.0	254.0	44.5	-	-	-	67.8
31.0	72.0	53.0	254.0	45.7	-	-	-	67.8

Cleaned with 4XMC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 4-Oct-88

Mode: RBM
Operator: PCF

Run Number: 23

Elapsed Time (min)	Temp. (°C)	HST-03			-			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				
0.0	75.0	57.0	255.5	67.1	-	-	-	0.0
22.0	75.0	57.0	256.0	54.0	-	-	-	5.7
42.0	75.0	57.0	255.0	64.1	-	-	-	9.2
67.0	75.0	57.0	255.0	62.9	-	-	-	11.5
139.0	75.0	57.0	258.0	49.3	-	-	-	20.1
273.0	75.0	57.0	251.5	<44.5	-	-	-	29.3
366.0	75.0	57.0	251.0	<44.5	-	-	-	33.9

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 5-Oct-88

Mode: Cleaning
Operator: PCF

Run Number: 23-C1

Elapsed Time (min)	Temp. (°C)	HST-03				-		% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				
0.0	40.0	49.0	253.5	<44	-	-	-	0.0
15.0	55.0	49.0	256.0	44.5	-	-	-	0.0
34.0	69.0	49.0	253.5	<44	-	-	-	0.0
65.0	76.0	49.0	249.5	<44	-	-	-	0.0
0.0	68.0	54.0	253.0	67.1	-	-	-	0.0
15.0	75.0	54.0	252.5	51.6	-	-	-	0.0
45.0	75.0	54.0	252.5	44.5	-	-	-	0.0
61.0	75.0	54.0	253.0	44.5	-	-	-	0.0
0.0	70.0	54.0	253.5	78.3	-	-	-	0.0
15.0	75.0	54.0	253.5	60.5	-	-	-	0.0
47.0	74.0	54.0	253.0	51.0	-	-	-	0.0
60.0	73.0	54.0	253.0	44.5	-	-	-	0.0

Cleaned with 4XMC-3 and 5% IPA and soaked overnight

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 6-Oct-88

Mode: Cleaning
Operator: PCF

Run Number: 23-C2

Elapsed Time (min)	Temp. (°C)	HST-03				-		% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				
3.0	35.0	45.0	253.0	120.5	-	-	-	0.0
10.0	36.0	45.0	253.0	181.0	-	-	-	0.0

Recirculated cleaner from previous day

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 6-Oct-88

Mode: RBM
Operator: PCF

Run Number: 24

Elapsed Time (min)	Temp. (°C)	HST-03				-		% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				
0.0	52.0	48.0	254.0	184.0	-	-	-	0.0
14.0	67.0	48.0	253.5	134.7	-	-	-	8.0
29.0	75.0	48.0	253.5	112.2	-	-	-	14.9
74.0	75.0	48.0	252.0	78.3	-	-	-	31.0
101.0	75.0	48.0	263.5	67.1	-	-	-	37.4
156.0	74.0	48.0	253.5	49.3	-	-	-	46.6
204.0	75.0	48.0	253.0	44.5	-	-	-	54.0
266.0	75.0	48.0	253.0	<44.5	-	-	-	60.9
321.0	74.0	48.0	253.5	<44.5	-	-	-	67.2
358.0	74.0	48.0	253.0	<44.5	-	-	-	72.4

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 11-Oct-88

Mode: Cleaning
Operator: PCF

Run Number: 24-C1

Elapsed Time (min)	Temp. (°C)	HST-03			HSC - 02			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	33.0	42.0	253.5	>593.5	81.0	253.5	123.4	0.0
30.0	41.0	44.0	253.5	>593.5	80.0	256.0	119.3	68.4

Cleaned with 4XMC-3

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 14-Oct-88

Mode: RBM
Operator: PCF

Run Number: 25

Elapsed Time (min)	Temp. (°C)	HEM - 04			EMPTY			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)				
0.0	51.0	65.0	254.5	359.1				0.0
13.0	62.0	65.0	255.0	337.1				17.2
25.0	75.0	65.0	252.5	348.4				32.2

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 26-Oct-88

Mode: MBM
Operator: PCF

Run Number: 26

	Elapsed Time (min)	Temp. (°C)	HEM-05			HEM - 06			% Volume Reduction
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
	0.0	67.0	-	-	-	72.0	256.0	224.3	0.0
	12.0	71.0	-	-	-	72.0	258.5	224.3	7.4
	17.0	75.0	-	-	-	72.0	259.0	236.2	10.2
	44.0	74.0	-	-	-	72.0	254.0	242.1	23.4
	91.0	75.0	-	-	-	72.0	253.0	242.1	39.1
	110.0	65.0	-	-	-	72.0	254.0	235.6	43.8
	125.0	69.0	-	-	-	72.0	254.0	235.6	46.9
	138.0	76.0	-	-	-	72.0	253.5	226.7	49.3
	148.0	75.0	-	-	-	72.0	254.0	224.3	50.9
	177.0	74.0	-	-	-	72.0	253.0	194.7	54.9
	205.0	71.0	-	-	-	72.0	253.5	179.8	57.9
	274.0	71.0	-	-	-	72.0	255.0		60.9
	323.0	74.0	-	-	-	72.0	255.5	142.4	62.4
	388.0	73.0	-	-	-	72.0	257.0		64.3
	448.0	73.0	-	-	-	72.0	257.0	112.8	65.5
27-Oct-88	508.0	73.0	-	-	-	71.0	256.0		66.7
	568.0	73.0	-	-	-	71.0	257.0	95.0	67.6
	628.0	73.0	-	-	-	71.0	257.5		68.4
	688.0	73.0	-	-	-	71.0	257.0	77.2	69.1
	748.0	73.0	-	-	-	71.0	257.0		69.8
	808.0	73.0	-	-	-	71.0	256.5	71.2	70.3
	868.0	73.0	-	-	-	71.0	257.0		70.9
	960.0	73.0	-	-	-	72.0	258.0	44.5	71.4

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 26-Oct-88

Mode: MBM
Operator: PCF

Run Number: 26

Elapsed Time (min)	Temp. (°C)	HEM-05 Flow Rate (L/min)*	HEM-05 Average Pressure (kPa)	HEM-05 Flux Rate (LMH)	HEM-06 Flow Rate (L/min)*	HEM-06 Average Pressure (kPa)	HEM-06 Flux Rate (LMH)	% Volume Reduction
1034.0	73.0	-	-	-	72.0	205.5	38.6	72.1
1075.0	73.0	-	-	-	72.0	205.5		72.3
1150.0	74.0	-	-	-	72.0	205.5	27.3	72.5
1268.0	74.0	-	-	-	72.0	207.5		72.9

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 27-Oct-88

Mode: Cleaning
Operator: PCF

Run Number: 26-C1

Elapsed Time (min)	Temp. (°C)	HEM-05			HEM-05			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	32.0	-	-	-	65.0	205.0	50.4	0.0
32.0	63.0	-	-	-	66.0	203.5	80.7	0.0
73.0	74.0	-	-	-	67.0	204.0	144.8	0.0
95.0	74.0	-	-	-	67.0	205.0	147.2	0.0
130.0	73.0	-	-	-	67.0	204.0	147.8	0.0
187.0	73.0	-	-	-	66.0	205.0	146.0	0.0

Cleaned with 6XMC-3 and 5% IPA

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 28-Oct-88

Mode: MBM
Operator: PCF

Run Number: 27

28-Oct-88

Elapsed Time (min)	Temp. (°C)	HEM - 05			HEM - 06			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	65.0	-	-	-	62.0	205.0	224.3	0.0
28.0	75.0	-	-	-	61.0	205.0	208.9	15.2
33.0	75.0	-	-	-	61.0	205.0	224.3	17.5
46.0	75.0	-	-	-	60.0	205.0	208.9	22.8
87.0	73.0	-	-	-	60.0	205.0	166.2	34.4
138.0	72.0	-	-	-	60.0	204.0	146.0	43.2
168.0	72.0	-	-	-	60.0	203.0	134.7	46.9
228.0	72.0	-	-	-	60.0	204.0	134.7	52.9
288.0	72.0	-	-	-	60.0	204.5	123.4	57.5
348.0	72.0	-	-	-	60.0	204.5	112.2	61.0
408.0	72.0	-	-	-	60.0	204.5	112.2	63.8
468.0	72.0	-	-	-	60.0	203.5	112.2	66.3
528.0	73.0	-	-	-	60.0	204.5	89.6	68.2
588.0	73.0	-	-	-	60.0	204.5	67.1	69.5
648.0	73.0	-	-	-	60.0	204.5	55.8	70.5
708.0	73.0	-	-	-	60.0	204.5	55.8	71.4
768.0	74.0	-	-	-	60.0	204.5	35.6	72.0
816.0	74.0	-	-	-	60.0	205.0	32.0	72.4
868.0	74.0	-	-	-	60.0	205.0	27.3	72.7
918.0	74.0	-	-	-	60.0	205.0	26.1	73.0
966.0	74.0	-	-	-	60.0	205.0	23.7	73.3
1038.0	74.0	-	-	-	60.0	205.0	21.4	73.6

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 28-Oct-88

Mode: Cleaning
Operator: PCF

Run Number: 27-C1

Elapsed Time (min)	Temp. (°C)	HEM - 05			HEM - 05			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	36.0	-	-	-	67.0	205.0	26.1	-
11.0	52.0	-	-	-	67.0	203.5	28.5	-
29.0	75.0	-	-	-	67.0	205.0	80.7	-
65.0	77.0	-	-	-	67.0	204.0	92.0	-
105.0	75.0	-	-	-	67.0	204.0	95.0	-
154.0	73.0	-	-	-	67.0	205.0	92.6	-
205.0	73.0	-	-	-	67.0	205.0	92.6	-
255.0	73.0	-	-	-	67.0	205.0	92.6	-

Cleaned with 4XMC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 29-Oct-88

Mode: MBM
Operator: PCF

Run Number: 28

	Elapsed Time (min)	Temp. (°C)	HEM - 05			HEM - 06			% Volume Reduction
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
	0.0	68.0	-	-	-	67.0	205.0	104.5	0.0
	15.0	75.0	-	-	-	67.0	205.0	134.7	5.1
	43.0	75.0	-	-	-	67.0	205.0	134.7	14.2
	72.0	74.0	-	-	-	67.0	205.0	123.4	21.6
	100.0	73.0	-	-	-	67.0	205.0	125.2	27.5
	132.0	73.0	-	-	-	67.0	205.0	123.4	33.2
	210.0	72.0	-	-	-	67.0	205.0	123.4	43.9
	270.0	72.0	-	-	-	67.0	205.0	112.2	49.8
	330.0	71.0	-	-	-	67.0	205.0	100.9	54.2
	390.0	71.0	-	-	-	67.0	205.0	89.6	57.5
29-Oct-88	450.0	71.0	-	-	-	66.0	205.0	78.3	60.0
	510.0	71.0	-	-	-	66.0	205.0	78.3	62.1
	570.0	71.0	-	-	-	66.0	205.0	67.1	63.9
	630.0	71.0	-	-	-	67.0	205.0	55.8	65.3
	690.0	71.0	-	-	-	66.0	205.0	33.2	66.2
	750.0	70.0	-	-	-	66.0	205.0	22.0	66.8
	810.0	74.0	-	-	-	66.0	205.0	17.8	67.1
	900.0	73.0	-	-	-	67.0	205.0	21.4	67.7
	950.0	72.0	-	-	-	67.0	205.0	19.6	68.0

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 29-Oct-88

Mode: Cleaning
Operator: PCF

Run Number: 28-C1

Elapsed Time (min)	Temp. (°C)	HEM - 05			HEM - 06			% Volume Reduction
		Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	
0.0	36.0	-	-	-	67.0	205.0	26.1	-
11.0	52.0	-	-	-	67.0	203.5	28.5	-
29.0	75.0	-	-	-	67.0	205.0	80.7	-
65.0	77.0	-	-	-	67.0	204.0	92.0	-
105.0	75.0	-	-	-	67.0	204.0	95.0	-
154.0	73.0	-	-	-	67.0	205.0	92.6	-
205.0	73.0	-	-	-	67.0	205.0	92.6	-
255.0	73.0	-	-	-	67.0	205.0	92.6	-

Cleaned with 4XMC-3

*Inaccurate values, see report Section 2.3.2

APPENDIX B

Site "A" - Analytical Data

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 18-Aug-88

Mode: RBM
Operator: JRI

Run Number: 1

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 01	% Rejection HEM - 01	Permeate HST - 01	% Rejection HST - 01
OIL						
TO (mg/L) (Lab #1)	105	711	47	93	27	96
TDO (mg/L) (Lab #1)	-	-	-	-	-	-
TO (mg/L) (Lab #2)	354	3530	47	99	34	99
TDO (mg/L) (Lab #2)	17	28	32	-14	18	36
SOLIDS						
Hydrocarbon (mg/L)	975	3870	4.7	100	11	100
TSS (mg/L)	130	180	15	92	14	92
TDS (mg/L)	4260	4320	4100	5	4220	2
IONS						
Ca (mg/L)	51	54	48	11	49	9
Mg (mg/L)	15	16	-	-	14	13
Si (mg/L)	79.1	74.9	74.3	1	74.2	1
Na (mg/L)	1180	1200	14	99	1110	8
Cl (mg/L)	1020	1050	947	10	954	9
HCO3 (mg/L)	1540	1540	1450	6	1460	5
SO4 (mg/L)	56	69	57	17	58	16
PHYSICAL						
Colour (APHA)	350	550	30	95	35	94
Resistivity (ohms) @ 25°C	1.707	1.73	1.78	-3	1.814	-5
Refractive Index @ 25°C	1.333	1.333	1.333	0	1.333	0
Relative Density @ 15°C	1.005	1.005	1.005	0	1.006	0
pH @ 23.5°C	7.9	8.1	8	1	8	1

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 18-Aug-88

Mode: RBM
Operator: JRI

Run
Number: 2

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 01	% Rejection HEM - 01	Permeate HST - 01	% Rejection HST - 01
OIL						
TO (mg/L) (Lab #1)	-	-	-	-	-	-
TDO (mg/L) (Lab #1)	-	-	-	-	-	-
TO (mg/L) (Lab #2)	-	-	-	-	-	-
TDO (mg/L) (Lab #2)	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	200	500	35	93	35	93
Resistivity (ohms) @ 25°C	-	-	-	-	-	-
Refractive Index @ 25°C	-	-	-	-	-	-
Relative Density @ 15°C	-	-	-	-	-	-
pH	6.75	7.15	7.15	0	7.15	0

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 18/8/1988

Mode: RBM
Operator: JRI

Run
Number: 3

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 01	% Rejection HEM - 01	Permeate HST - 01	% Rejection HST - 01
OIL						
TO (mg/L) (Lab #1)	162	139	15	89	31	78
TDO (mg/L) (Lab #1)	59	1	15	-1400	31	-3000
TO (mg/L) (Lab #2)	811	3034	154	95	135	96
TDO (mg/L) (Lab #2)	94	67	89	-33	99	-48
SOLIDS						
Hydrocarbon (mg/L)	535	1415	10	99	35	98
TSS (mg/L)	100	150	65	57	70	53
TDS (mg/L)	5130	5310	5150	3	5190	2
IONS						
Ca (mg/L)	67	71	65	8	65	8
Mg (mg/L)	14	14	13	7	14	0
Si (mg/L)	94.1	88.8	92.1	-4	91.5	-3
Na (mg/L)	1540	1520	1500	1	1420	7
Cl (mg/L)	1440	1370	1390	-1	1240	9
HCO3 (mg/L)	1820	1870	1780	5	1810	3
SO4 (mg/L)	60	68	60	12	65	4
PHYSICAL						
Colour (APHA)	120	350	60	83	55	84
Resistivity (ohms) @ 25°C	1.387	1.365	1.418	-4	1.404	-3
Refractive Index @ 25°C	1.334	1.334	1.333	0	1.334	0
Relative Density @ 15°C	1.005	1.005	1.003	0	1.003	0
pH @ 21.6°C	7.9	8.2	8.1	1	8	2

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A" Mode: RBM Run
Date: 22-Aug-88 Operator: PCF Number: 4

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 01	% Rejection HEM - 01	Permeate HST - 01	% Rejection HST - 01
OIL						
TO (mg/L) (Lab #1)	251	710	55	92	60	92
TDO (mg/L) (Lab #1)	41	8	55	-588	60	-650
TO (mg/L) (Lab #2)	886	5060	139	97	62	99
TDO (mg/L) (Lab #2)	95	100	-	-	60	40
SOLIDS						
Hydrocarbon (mg/L)	780	4935	40	99	25	99
TSS (mg/L)	195	595	50	92	60	90
TDS (mg/L)	4500	4810	4630	4	4550	5
IONS						
Ca (mg/L)	54	61	52	15	45	26
Mg (mg/L)	13	12	14	-17	12	0
Si (mg/L)	82.3	87.5	81.1	7	81.1	7
Na (mg/L)	1290	1380	1300	6	1340	3
Cl (mg/L)	1140	1160	1100	5	1130	3
HCO3 (mg/L)	1630	1830	1710	7	1720	6
SO4 (mg/L)	56	74	60	19	63	15
PHYSICAL						
Colour (APHA)	400	1000	70	93	70	93
Resistivity (ohms) @ 25°C	1.581	1.512	1.565	-4	1.571	-4
Refractive Index @ 25°C	1.333	1.333	1.333	0	1.333	0
Relative Density @ 15°C	1.003	1.001	1.001	0	1.001	0
pH @ 22.0°C	7.5	8.1	7.8	4	7.9	2

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 23-Aug-88

Mode: RBM
Operator: PCF

Run Number: 5

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 01	% Rejection HEM - 01	Permeate HST - 01	% Rejection HST - 01
OIL						
TO (mg/L) (Lab #1)	156	1324	30	98	46	97
TDO (mg/L) (Lab #1)	24	25	30	-20	46	-84
TO (mg/L) (Lab #2)	1041	4660	167	96	131	97
TDO (mg/L) (Lab #2)	60	69	70	-1	-	-
SOLIDS						
Hydrocarbon (mg/L)	880	4445	40	99	45	99
TSS (mg/L)	100	195	50	74	50	74
TDS (mg/L)	4920	5320	5000	6	5080	5
IONS						
Ca (mg/L)	53	61	49	20	44	28
Mg (mg/L)	15	15	12	20	14	7
Si (mg/L)	89.5	88.5	90.1	-2	89.7	-1
Na (mg/L)	1360	1480	1360	8	1400	5
Cl (mg/L)	1140	1220	1120	8	1130	7
HCO3 (mg/L)	1820	1990	1830	8	1900	5
SO4 (mg/L)	54	71	57	20	57	20
PHYSICAL						
Colour (APHA)	350	800	80	90	80	90
Resistivity (ohms) @ 25°C	1.465	1.391	1.435	-3	1.435	-3
Refractive Index @ 25°C	1.333	1.333	1.333	0	1.334	0
Relative Density @ 15°C	1.003	0.999	1.003	0	1.003	0
pH @ 21.9°C	7.5	8.1	8	1	8	1

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 26-Aug-88

Mode: RBM
Operator: PCF

Run Number: 6

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 01	% Rejection HEM - 01	Permeate HSC-01	% Rejection HSC-01
OIL						
TO (mg/L) (Lab #1)	814	3346	-	-	-	-
TDO (mg/L) (Lab #1)	37	32	-	-	-	-
TO (mg/L) (Lab #2)	1001	5580	135	98	148	97
TDO (mg/L) (Lab #2)	60	29	96	-231	90	-210
SOLIDS						
Hydrocarbon (mg/L)	770	5190	70	99	55	99
TSS (mg/L)	120	220	65	70	60	73
TDS (mg/L)	5047	5080	5100	0	5005	1
IONS						
Ca (mg/L)	58	65	58	11	61	6
Mg (mg/L)	0.75	19	17	11	17	11
Si (mg/L)	90.2	90.5	89.3	1	90.5	0
Na (mg/L)	1580	1530	1360	11	1530	0
Cl (mg/L)	1460	1290	1120	13	1270	2
HCO3 (mg/L)	1870	2040	1830	10	2050	0
SO4 (mg/L)	61	85	57	33	77	9
PHYSICAL						
Colour (APHA)	300	1250	60	95	50	96
Resistivity (ohms) @ 25°C	1.417	1.372	1.405	-2	1.395	-2
Refractive Index @ 25°C	1.333	1.334	1.334	0	1.333	0
Relative Density @ 15°C	1.005	1.005	1.005	0	1.004	0
pH @ 21.9°C	7.2	7.4	7.2	3	7.5	-1

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 30-Aug-88

Mode: RBM
Operator: PCF

Run Number: 8

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 01	% Rejection HEM - 01
OIL				
TO (mg/L) (Lab #1)	531	2719	115	96
TDO (mg/L) (Lab #1)	79	72	115	-60
TO (mg/L) (Lab #2)	971	5500	218	96
TDO (mg/L) (Lab #2)	59	31	57	-84
SOLIDS				
Hydrocarbon (mg/L)	875	5060	150	97
TSS (mg/L)	100	255	75	71
TDS (mg/L)	2940	3510	3489	1
IONS				
Ca (mg/L)	35	45	38	16
Mg (mg/L)	14	14	11	21
Si (mg/L)	-	-	-	-
Na (mg/L)	999	1180	1100	7
Cl (mg/L)	939	1090	1010	7
HCO3 (mg/L)	1150	1380	1270	8
SO4 (mg/L)	47	66	60	9
PHYSICAL				
Colour (APHA)	250	700	70	90
Resistivity (ohms) @ 25°C	2.274	1.966	2.055	-5
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C.	1.003	1.003	1.004	0
pH @ 21.9°C	7.5	8.3	7.8	6

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 6-Sep-88

Mode: RBM
Operator: PCF

Run
Number: 10

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-01	% Rejection HEM-01	Permeate -	% Rejection -
OIL						
TO (mg/L) (Lab #1)	540	119	129	-8	-	-
TDO (mg/L) (Lab #1)	65	-	-	-	-	-
TO (mg/L) (Lab #2)	1030	1150	228	80	-	-
TDO (mg/L) (Lab #2)	99	65	82	-26	-	-
SOLIDS						
Hydrocarbon (mg/L)	740	1040	130	88	-	-
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	300	500	85	83	-	-
Resistivity (ohms) @ 25°C	-	-	-	-	-	-
Refractive Index @ 25°C	-	-	-	-	-	-
Relative Density @ 15°C	-	-	-	-	-	-
pH	6.9	7.05	7.1	-1	-	-

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 12-Sep-88

Mode: RBM
Operator: PCF

Run Number: 11

PARAMETERS	Source Feed	Membrane Feed	Permeate HST-01	% Rejection HST-01	Permeate -	% Rejection -
OIL						
TO (mg/L) (Lab #1)	709	3879	90	98	-	-
TDO (mg/L) (Lab #1)	-	-	-	-	-	-
TO (mg/L) (Lab #2)	970	4145	119	97	-	-
TDO (mg/L) (Lab #2)	77	91	87	4	-	-
SOLIDS						
Hydrocarbon (mg/L)	855	3990	30	99	-	-
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL	-	-	-	-	-	-
Colour (APHA)	250	1200	65	95		
Resistivity (ohms) @ 25°C	-	-	-	-	-	-
Refractive Index @ 25°C	-	-	-	-	-	-
Relative Density @ 15°C	-	-	-	-	-	-
pH	6.85	7.05	7.1	-1	-	-

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 15-Sep-88

Mode: RBM
Operator: PCF

Run Number: 12

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-02	% Rejection HEM-02	Permeate -	% Rejection -
OIL						
TO (mg/L) (Lab #1)	111	521	106	80	-	-
TDO (mg/L) (Lab #1)	93	66	-	-	-	-
TO (mg/L) (Lab #2)	203	745	125	83	-	-
TDO (mg/L) (Lab #2)	94	72	92	-28	-	-
SOLIDS						
Hydrocarbon (mg/L)	80	730	75	90	-	-
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	150	400	55	86	-	-
Resistivity (ohms) @ 25°C	-	-	-	-	-	-
Refractive Index @ 25°C	-	-	-	-	-	-
Relative Density @ 15°C	-	-	-	-	-	-
pH	7	7.05	7.2	-2	-	-

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 16-Sep-88

Mode: RBM
Operator: PCF

Run Number: 13

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-02	% Rejection HEM-02	Permeate -	% Rejection -
OIL						
TO (mg/L) (Lab #1)	144	213	128	40	-	-
TDO (mg/L) (Lab #1)	52	71	-	-	-	-
TO (mg/L) (Lab #2)	259	301	130	57	-	-
TDO (mg/L) (Lab #2)	84	77	93	-21	-	-
SOLIDS						
Hydrocarbon (mg/L)	110	301	65	78	-	-
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	150	410	65	84	-	-
Resistivity (ohms) @ 25°C	-	-	-	-	-	-
Refractive Index @ 25°C	-	-	-	-	-	-
Relative Density @ 15°C	-	-	-	-	-	-
pH	7.05	7.15	6.85	4	-	-

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 19-Sep-88
Mode: RBM
Operator: JRI
Run Number: 14

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-02	% Rejection HEM-02	Permeate HST-02	% Rejection HST-02
OIL						
TO (mg/L) (Lab #1)	144	3346	66	98	48	99
TDO (mg/L) (Lab #1)	113	32	66	-106	48	-50
TO (mg/L) (Lab #2)	132	68	64	6	58	15
TDO (mg/L) (Lab #2)	99	99	89	10	70	29
SOLIDS						
Hydrocarbon (mg/L)	98	16	6	63	3	81
TSS (mg/L)	46	29	21	28	23	21
TDS (mg/L)	5450	5550	5440	2	5470	1
IONS						
Ca (mg/L)	63	67	61	9	67	0
Mg (mg/L)	16	14	15	-7	16	-14
Si (mg/L)	216	212	210	1	208	2
Na (mg/L)	1830	1940	1800	7	1860	4
Cl (mg/L)	1730	1850	1670	10	1730	6
HCO3 (mg/L)	2100	2170	2100	3	2180	0
SO4 (mg/L)	51	54	49	9	51	6
PHYSICAL						
Colour (APHA)	80	95	60	37	60	37
Resistivity (ohms) @ 25°C	1.544	1.252	1.274	-2	1.271	-2
Refractive Index @ 25°C	1.333	1.333	1.333	0	1.333	0
Relative Density @ 15°C	1.006	1.005	1.004	0	1.004	0
pH @ 20.9°C	8.1	8.2	8.2	0	8.1	1

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 19-Sep-88

Mode: RBM
Operator: JRI

Run Number: 15

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-02	% Rejection HEM-02	Permeate HST-02	% Rejection HST-02
OIL						
TO (mg/L) (Lab #1)	144	108	107	1	125	-16
TDO (mg/L) (Lab #1)	113	118	-	-	-	-
TO (mg/L) (Lab #2)	132	68	64	6	58	15
TDO (mg/L) (Lab #2)	99	99	89	10	70	29
SOLIDS						
Hydrocarbon (mg/L)	105	55	15	73	65	-18
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	85	95	65	32	65	32
Resistivity (ohms) @ 25°C	-	-	-	-	-	-
Refractive Index @ 25°C	-	-	-	-	-	-
Relative Density @ 15°C	-	-	-	-	-	-
pH @ 20.9°C	-	-	-	-	-	-

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 20-Sep-88
Mode: RBM
Operator: JRI
Run Number: 17

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-02	% Rejection HEM-02	Permeate HST-02	% Rejection HST-02
OIL						
TO (mg/L) (Lab #1)	146	91	83	9	114	-25
TDO (mg/L) (Lab #1)	143	80	-	-	-	-
TO (mg/L) (Lab #2)	97	86	81	6	80	7
TDO (mg/L) (Lab #2)	84	79	76	4	56	29
SOLIDS						
Hydrocarbon (mg/L)	98	16	6	63	3	81
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	100	100	80	20	80	20
Resistivity (ohms) @ 25°C	-	-	-	-	-	-
Refractive Index @ 25°C	-	-	-	-	-	-
Relative Density @ 15°C	-	-	-	-	-	-
pH @ 20.9°C	-	-	-	-	-	-

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 23-Sep-88

Mode: RBM
Operator: JRI

Run Number: 18

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-02	% Rejection HEM-O2	Permeate HST-02	% Rejection HST-02
OIL						
TO (mg/L) (Lab #1)	531	2719	115	96	-	-
TDO (mg/L) (Lab #1)	79	72	115	-60	-	-
TO (mg/L) (Lab #2)	128	96	83	14	64	33
TDO (mg/L) (Lab #2)	136	88	84	5	44	50
SOLIDS						
Hydrocarbon (mg/L)	55	22	3	86	2	91
TSS (mg/L)	52	234	84	64	69	71
TDS (mg/L)	4810	4910	4370	11	4450	9
IONS						
Ca (mg/L)	67	64	58	9	52	19
Mg (mg/L)	18	17	16	6	15	12
Si (mg/L)	206.7	195	189.3	3	190.8	2
Na (mg/L)	1740	1650	1660	-1	1570	5
Cl (mg/L)	1650	1540	1620	-5	1510	2
HCO3 (mg/L)	2010	1940	1830	6	1770	9
SO4 (mg/L)	45	47	35	26	35	26
PHYSICAL						
Colour (APHA)	150	400	150	63	180	55
Resistivity (ohms) @ 25°C	1.306	1.366	1.423	-4	1.45	-6
Refractive Index @ 25°C	1.333	1.333	1.333	0	1.333	0
Relative Density @ 15°C	1.005	1.005	1.005	0	1.004	0
pH @ 21.7°C	7.3	7.3	7.5	-3	7.4	-1

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"   Mode: RBM   Run
Date: 26-Sep-88   Operator: PCF   Number: 19

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-02	% Rejection HEM-02	Permeate HST-02	% Rejection HST-02
OIL						
TO (mg/L) (Lab #1)	132	3346	66	98	48	99
TDO (mg/L) (Lab #1)	112	32	66	-106	48	-50
TO (mg/L) (Lab #2)	111	79	57	28	57	28
TDO (mg/L) (Lab #2)	94	82	72	12	47	43
SOLIDS						
Hydrocarbon (mg/L)	106	10	2	80	<.1	99
TSS (mg/L)	82	206	90	56	80	61
TDS (mg/L)	4690	4510	4320	4	4160	8
IONS						
Ca (mg/L)	61	59	51	14	49	17
Mg (mg/L)	17	16	14	13	14	13
Si (mg/L)	190	180	178	1	176	2
Na (mg/L)	1340	1330	1310	2	1260	5
Cl (mg/L)	1190	1190	1190	0	1160	3
HCO3 (mg/L)	1720	1680	1550	8	1530	9
SO4 (mg/L)	45	39	72	-85	34	13
PHYSICAL						
Colour (APHA)	110	150	55	63	60	60
Resistivity (ohms) @ 25°C	1.471	1.52	1.622	-7	1.643	-8
Refractive Index @ 25°C	1.334	1.334	1.333	0	1.334	0
Relative Density @ 15°C	1.001	1.003	1.003	0	1.003	0
pH @ 20.9°C	7.8	8	8.1	-1	8	0

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 30-Sep-88

Mode: RBM
Operator: PCF

Run Number: **20**

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-02	% Rejection HEM-02	Permeate HST-02	% Rejection HST-02
OIL						
TO (mg/L) (Lab #1)	317	-	-	-	-	-
TDO (mg/L) (Lab #1)	43	-	-	-	-	-
TO (mg/L) (Lab #2)	-	-	-	-	-	-
TDO (mg/L) (Lab #2)	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	90	140	60	57	-	-
Resistivity (ohms) @ 25°C	-	-	-	-	-	-
Refractive Index @ 25°C	-	-	-	-	-	-
Relative Density @ 15°C	-	-	-	-	-	-
pH @ 20.9°C	7.1	7.5	7.5	0	-	-

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 30-Sep-88

Mode: RBM
Operator: PCF

Run Number: 21

PARAMETERS	Source Feed	Membrane Feed	Permeate HST-03	% Rejection HST-03
OIL				
TO (mg/L) (Lab #1)	65	72	39	46
TDO (mg/L) (Lab #1)	40	27	-	-
TO (mg/L) (Lab #2)	126	110	90	18
TDO (mg/L) (Lab #2)	123	163	112	31
TO (mg/L) (Lab #3, Freon)	39.1	40.6	20.7	49
SOLIDS				
Hydrocarbon (mg/L)	56	10	<.1	99
TSS (mg/L)	56	60	36	40
TDS (mg/L)	5270	5660	5470	3
IONS				
Ca (mg/L)	69	75	72	4
Mg (mg/L)	20	21	20	5
Si (mg/L)	209	211	203	4
Na (mg/L)	1550	1550	1500	3
Cl (mg/L)	1430	1430	1350	6
HCO3 (mg/L)	1900	1740	1890	-9
SO4 (mg/L)	46	47	34	28
PHYSICAL				
Colour (APHA)	80	110	55	50
Resistivity (ohms) @ 25°C	1.339	1.288	1.322	-3
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.003	1.003	1.003	0
pH @ 21.7°C	7.9	8.6	8.4	2

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 3-Oct-88

Mode: RBM
Operator: PCF

Run Number: 22

PARAMETERS	Source Feed	Membrane Feed	Permeate HST-03	% Rejection HST-03
OIL				
TO (mg/L) (Lab #1)	105	110	34	69
TDO (mg/L) (Lab #1)	35	24	-	-
TO (mg/L) (Lab #2)	367	217	78	64
TDO (mg/L) (Lab #2)	44	82	56	32
TO (mg/L) (Lab #3, Freon)	25.5	17.5	17.2	2
TDO (mg/L) (Lab #3, Freon)	23.5	15.2	14.4	5
SOLIDS				
Hydrocarbon (mg/L)	264	190	6	97
TSS (mg/L)	116	190	42	78
TDS (mg/L)	4150	4210	4240	-1
IONS				
Ca (mg/L)	48	48	39	19
Mg (mg/L)	14	14	12	14
Si (mg/L)	171	172	162	6
Na (mg/L)	1160	1170	1100	6
Cl (mg/L)	970	948	895	6
HCO3 (mg/L)	1590	1630	1500	8
SO4 (mg/L)	32	50	40	20
PHYSICAL				
Colour (APHA)	250	450	45	90
Resistivity (ohms) @ 25°C	1.748	1.725	1.818	-5
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.002	1.002	1.002	0
pH @ 20.9°C	7.9	8.2	7.9	4

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"	Mode: RBM	Run
Date: 4-Oct-88	Operator: PCF	Number: 23

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM-02	% Rejection HEM-02	Permeate HST-02	% Rejection HST-02
OIL						
TO (mg/L) (Lab #1)	331	-	-	-	-	-
TDO (mg/L) (Lab #1)	100	-	-	-	-	-
TO (mg/L) (Lab #2)	350	-	-	-	-	-
TDO (mg/L) (Lab #2)	108	-	-	-	-	-
SOLIDS	-	-	-	-	-	-
Hydrocarbon (mg/L)	204	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms) @ 25°C	-	-	-	-	-	-
Refractive Index @ 25°C	-	-	-	-	-	-
Relative Density @ 15°C	-	-	-	-	-	-
pH @ 20.9°C	-	-	-	-	-	-

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 6-Oct-88

Mode: RBM
Operator: PCF

Run Number: 24

PARAMETERS	Source Feed	Membrane Feed	Permeate HST-03	% Rejection HST-03
OIL				
TO (mg/L) (Lab #1)	192	179	124	31
TDO (mg/L) (Lab #1)	69	59	124	-110
TO (mg/L) (Lab #2)	248	205	196	4
TDO (mg/L) (Lab #2)	108	72	58	19
SOLIDS				
Hydrocarbon (mg/L)	26	114	38	67
TSS (mg/L)	18	46	30	35
TDS (mg/L)	4780	5090	4920	3
IONS				
Ca (mg/L)	57	52	53	-2
Mg (mg/L)	18	17	17	0
Si (mg/L)	194	194	192	1
Na (mg/L)	1460	1490	1440	3
Cl (mg/L)	1200	1260	1230	2
HCO3 (mg/L)	2000	1960	1880	4
SO4 (mg/L)	58	62	56	10
Fe(mg/L)	0.1	0.1	<.1	-
Al(mg/L)	<.5	<.5	<.5	-
Ba(mg/L)	1.1	1.1	1.1	0
PHYSICAL				
Colour (APHA)	185	300	100	67
Resistivity (ohms) @ 25°C	1.36	1.373	1.394	-2
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.003	1.003	1.002	0
pH @ 20.9°C	7.7	8.3	8.3	0

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 26-Oct-88
Time: 17:10

Mode: MBM
Operator: PCF

Run Number: **26A**

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 06	% Rejection HEM - 06
OIL				
TO (mg/L) (Lab #1)	513	1324	-	-
TDO (mg/L) (Lab #1)	29	32	-	-
TO (mg/L) (Lab #2)	656	2133	-	-
TDO (mg/L) (Lab #2)	109	60	-	-
SOLIDS				
Hydrocarbon (mg/L)	408	2160	-	-
TSS (mg/L)	80	176	-	-
TDS (mg/L)	5430	5010	-	-
IONS				
Ca (mg/L)	55	56	-	-
Mg (mg/L)	16	19	-	-
Si (mg/L)	224	229	-	-
Na (mg/L)	1540	1530	-	-
Cl (mg/L)	1350	1270	-	-
HCO3 (mg/L)	2000	2060	-	-
SO4 (mg/L)	10	67	-	-
Fe(mg/L)	3.3	1.9	-	-
Al(mg/L)	<.5	<.5	-	-
Ba(mg/L)	0.9	0.9	-	-
PHYSICAL				
Colour (APHA)	350	500	-	-
Resistivity (ohms) @ 25°C	1.354	1.328	-	-
Refractive Index @ 25°C	1.333	1.333	-	-
Relative Density @ 15°C	1.001	1.003	-	-
pH @ 21.6°C	8	8.1	-	-

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 27-Oct-88
Time: 8:30

Mode: MBM
Operator: PCF

Run Number: **26B**

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 06	% Rejection HEM - 06
OIL				
TO (mg/L) (Lab #1)	446	569	108	81
TDO (mg/L) (Lab #1)	58	65	108	-66
TO (mg/L) (Lab #2)	705	637	126	80
TDO (mg/L) (Lab #2)	63	71	74	-4
SOLIDS				
Hydrocarbon (mg/L)	500	370	62	83
TSS (mg/L)	106	84	46	45
TDS (mg/L)	5530	5550	5270	5
IONS				
Ca (mg/L)	62	63	56	11
Mg (mg/L)	20	20	19	5
Si (mg/L)	230	231	226	2
Na (mg/L)	1560	1540	1490	3
Cl (mg/L)	1290	1280	1310	-2
HCO3 (mg/L)	2120	1990	1830	8
SO4 (mg/L)	65	66	50	24
Fe(mg/L)	2.4	0.3	<.1	-
Al(mg/L)	<.5	<.5	<.5	-
Ba(mg/L)	1	1	0.9	10
PHYSICAL				
Colour (APHA)	300	450	70	84
Resistivity (ohms) @ 25°C	1.345	1.02	1.399	-37
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.003	1.003	1.003	0
pH @ 21.6°C	8.3	8.4	8.4	0

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 27-Oct-88
Time: 11:00

Mode: MBM
Operator: PCF

Run Number: 26C

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 06	% Rejection HEM - 06
OIL				
TO (mg/L) (Lab #1)	397	410	137	67
TDO (mg/L) (Lab #1)	88	56	137	-145
TO (mg/L) (Lab #2)	568	591	123	79
TDO (mg/L) (Lab #2)	85	59	116	-97
SOLIDS				
Hydrocarbon (mg/L)	428	464	48	90
TSS (mg/L)	102	94	50	47
TDS (mg/L)	5570	5630	5320	6
IONS				
Ca (mg/L)	63	63	56	11
Mg (mg/L)	20	20	17	15
Si (mg/L)	231	246	242	2
Na (mg/L)	1640	1670	3980	-138
Cl (mg/L)	1430	1490	1290	13
HCO3 (mg/L)	2100	2090	1940	7
SO4 (mg/L)	66	65	TOO HIGH	-
Fe(mg/L)	1.5	0.2	<.1	-
Al(mg/L)	<.5	<.5	<.5	-
Ba(mg/L)	1	1	0.9	10
PHYSICAL				
Colour (APHA)	300	400	65	84
Resistivity (ohms) @ 25°C	1.308	1.323	1.362	-3
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.002	1.003	1.001	0
pH @ 21.6°C	8.3	8.3	8	4

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 27-Oct-88
Time: 17:00

Mode: MBM
Operator: PCF

Run Number: 27A

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 06	% Rejection HEM - 06
OIL				
TO (mg/L) (Lab #1)	474	422	50	88
TDO (mg/L) (Lab #1)	75	54	50	7
TO (mg/L) (Lab #2)	840	901	93	90
TDO (mg/L) (Lab #2)	51	82	74	10
SOLIDS				
Hydrocarbon (mg/L)	740	750	22	97
TSS (mg/L)	80	88	34	61
TDS (mg/L)	5650	5760	4898	15
IONS				
Ca (mg/L)	58	60	42	30
Mg (mg/L)	18	18	15	17
Si (mg/L)	241	240	227	5
Na (mg/L)	1530	1590	1500	6
Cl (mg/L)	1270	1300	1140	12
HCO3 (mg/L)	2060	2170	2150	1
SO4 (mg/L)	60	61	51	16
Fe(mg/L)	0.4	0.3	0.2	33
Al(mg/L)	<.5	<.5	<.5	-
Ba(mg/L)	0.9	0.9	<.5	-
PHYSICAL				
Colour (APHA)	300	300	55	82
Resistivity (ohms) @ 25°C	1.34	1.342	1.399	-4
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.003	1.003	1.003	0
pH @ 21.6°C	8.3	8.2	8.4	-2

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 27-Oct-88
Time: 23:00

Mode: MBM
Operator: PCF

Run Number: 27B

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 06	% Rejection HEM - 06
OIL				
TO (mg/L) (Lab #1)	397	446	54	88
TDO (mg/L) (Lab #1)	41	30	54	-80
TO (mg/L) (Lab #2)	580	674	115	83
TDO (mg/L) (Lab #2)	79	94	96	-2
SOLIDS				
Hydrocarbon (mg/L)	520	416	14	97
TSS (mg/L)	118	78	56	28
TDS (mg/L)	5350	5610	5200	7
IONS				
Ca (mg/L)	58	58	52	10
Mg (mg/L)	18	18	17	6
Si (mg/L)	245	247	242	2
Na (mg/L)	1490	1540	1510	2
Cl (mg/L)	1180	1260	1280	-2
HCO3 (mg/L)	2100	2110	1980	6
SO4 (mg/L)	62	61	51	16
Fe(mg/L)	<.1	<.1	<.1	-
Al(mg/L)	0.8	0.9	0.6	33
Ba(mg/L)	0.8	0.8	0.8	0
PHYSICAL				
Colour (APHA)	300	400	70	83
Resistivity (ohms) @ 25°C	1.342	1.328	1.388	-5
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.003	1.003	1.003	0
pH @ 21.6°C	8.2	7.9	7.9	0

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 28-Oct-88
Time: 8:45

Mode: MBM
Operator: PCF

Run Number: 27C

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 06	% Rejection HEM - 06
OIL				
TO (mg/L) (Lab #1)	264	264	93	65
TDO (mg/L) (Lab #1)	37	46	93	-102
TO (mg/L) (Lab #2)	303	480	158	67
TDO (mg/L) (Lab #2)	70	48	126	-163
SOLIDS				
Hydrocarbon (mg/L)	633	300	105	65
TSS (mg/L)	148	98	73	26
TDS (mg/L)	5490	5540	5270	5
IONS				
Ca (mg/L)	63	61	58	5
Mg (mg/L)	17	17	16	6
Si (mg/L)	236	235	236	0
Na (mg/L)	1530	1560	1490	4
Cl (mg/L)	1260	1330	1280	4
HCO3 (mg/L)	2030	2040	1940	5
SO4 (mg/L)	62	68	55	19
Fe(mg/L)	<.1	<.1	<.1	-
Al(mg/L)	<.5	<.5	<.5	-
Ba(mg/L)	0.8	0.8	0.8	0
PHYSICAL				
Colour (APHA)	250	300	70	77
Resistivity (ohms) @ 25°C	1.342	1.328	1.372	-3
Refractive Index @ 25°C	1.334	1.333	1.334	0
Relative Density @ 15°C	1.002	1.003	1.001	0
pH @ 21.6°C	8.3	7.9	8	-1

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 28-Oct-88
Time: 16:30

Mode: MBM
Operator: PCF

Run Number: 28A

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 06	% Rejection HEM - 06
OIL				
TO (mg/L) (Lab #1)	374	358	106	70
TDO (mg/L) (Lab #1)	54	55	106	-93
TO (mg/L) (Lab #2)	660	686	111	84
TDO (mg/L) (Lab #2)	163	91	93	-2
SOLIDS				
Hydrocarbon (mg/L)	745	675	60	91
TSS (mg/L)	115	100	38	62
TDS (mg/L)	5370	5460	5900	-8
IONS				
Ca (mg/L)	62	63	42	33
Mg (mg/L)	17	17	13	24
Si (mg/L)	231	232	210	9
Na (mg/L)	1530	1510	1540	-2
Cl (mg/L)	1300	1260	1150	9
HCO3 (mg/L)	2030	2050	2230	-9
SO4 (mg/L)	55	62	56	10
Fe(mg/L)	1.1	0.1	0.2	-100
Al(mg/L)	<.5	<.5	0.8	-
Ba(mg/L)	0.8	0.8	<.5	-
PHYSICAL				
Colour (APHA)	350	350	45	87
Resistivity (ohms) @ 25°C	1.336	1.332	1.333	0
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.001	1.001	1.002	0
pH @ 21.6°C	8.1	8.1	8.1	0

File No. CO874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 28-Oct-88
Time: 23:00

Mode: MBM
Operator: PCF

Run Number: 28B

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 06	% Rejection HEM - 06
OIL				
TO (mg/L) (Lab #1)	496	368	86	77
TDO (mg/L) (Lab #1)	102	71	86	-21
TO (mg/L) (Lab #2)	490	589	124	79
TDO (mg/L) (Lab #2)	100	100	138	-38
SOLIDS				
Hydrocarbon (mg/L)	435	430	58	87
TSS (mg/L)	115	110	65	41
TDS (mg/L)	5460	5480	5220	5
IONS				
Ca (mg/L)	61	62	57	8
Mg (mg/L)	17	17	16	6
Si (mg/L)	231	231	229	1
Na (mg/L)	1560	1530	1550	-1
Cl (mg/L)	1360	1280	1400	-9
HCO3 (mg/L)	1950	2050	1880	8
SO4 (mg/L)	61	63	54	14
Fe(mg/L)	<.1	<.1	0.1	-
Al(mg/L)	<.5	<.5	<.5	-
Ba(mg/L)	0.9	0.9	0.8	11
PHYSICAL				
Colour (APHA)	300	300	70	77
Resistivity (ohms) @ 25°C	1.337	1.333	1.378	-3
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.002	1.002	1.002	0
pH @ 21.6°C	8.4	8.3	8.2	1

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "A"
Date: 29-Oct-88
Time: 8:30

Mode: MBM
Operator: PCF

Run Number: 28C

PARAMETERS	Source Feed	Membrane Feed	Permeate HEM - 06	% Rejection HEM - 06
OIL				
TO (mg/L) (Lab #1)	373	411	121	71
TDO (mg/L) (Lab #1)	71	70	121	-73
TO (mg/L) (Lab #2)	329	571	135	76
TDO (mg/L) (Lab #2)	86	55	113	-105
SOLIDS				
Hydrocarbon (mg/L)	375	443	75	83
TSS (mg/L)	130	120	85	29
TDS (mg/L)	5470	5400	5010	7
IONS				
Ca (mg/L)	63	62	58	6
Mg (mg/L)	17	17	17	0
Si (mg/L)	231	232	228	2
Na (mg/L)	1520	1610	1540	4
Cl (mg/L)	1270	1400	1370	2
HCO3 (mg/L)	2030	2060	1930	6
SO4 (mg/L)	65	60	50	17
Fe(mg/L)	0.1	0.1	<.1	-
Al(mg/L)	<.5	<.5	<.5	-
Ba(mg/L)	0.9	0.9	0.8	11
PHYSICAL				
Colour (APHA)	200	250	40	84
Resistivity (ohms) @ 25°C	1.336	1.334	1.351	-1
Refractive Index @ 25°C	1.333	1.333	1.333	0
Relative Density @ 15°C	1.002	1.002	1.003	0
pH @ 21.6°C	8.2	8.2	8.2	0

APPENDIX C

Site "B" - Operating Data

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 17-Jan-89

Mode: Stability
Operator: PCF/JRI

Run Number: 1

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-03			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
0.0	71.5	415.0	38.0	257.5	-	80.0	257.5	-	-
15.0	71.5	415.0	38.0	257.5	461.7	80.0	257.5	336.5	-
30.0	73.0	420.0	38.0	260.0	456.4	80.0	261.5	325.2	-
60.0	75.0	420.0	38.0	260.0	441.0	80.0	265.0	359.7	-
90.0	75.5	420.0	38.0	262.5	464.7	80.0	260.0	347.8	-
120.0	75.0	410.0	38.0	255.0	435.6	80.0	255.0	325.8	-
150.0	75.5	415.0	38.0	257.5	426.1	80.0	257.5	325.8	-
180.0	75.0	420.0	38.0	260.0	441.0	80.0	260.0	325.8	-
210.0	75.0	415.0	38.0	257.5	429.1	80.0	257.5	321.1	-

Cleaned for 1 hour with MC-3.

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 18-Jan-89

Mode: Stability
Operator: PCF/JRI

Run Number: 2

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-03			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
0.0	72.0	410.0	34.0	255.0	392.9	80.0	255.0	426.7	-
15.0	72.0	410.0	34.0	255.0	381.6	80.0	255.0	426.7	-
30.0	73.0	410.0	34.0	255.0	370.9	80.0	256.5	422.6	-
45.0	73.0	410.0	34.0	255.0	363.8	80.0	260.0	406.5	-
60.0	75.5	410.0	35.0	255.0	359.7	80.0	255.0	388.7	-
75.0	75.0	410.0	35.0	255.0	356.7	80.0	255.0	381.6	-
90.0	75.5	410.0	35.0	255.0	354.9	80.0	255.0	372.7	-
105.0	75.0	410.0	35.0	255.0	347.8	80.0	255.0	381.6	-
120.0	75.5	410.0	35.0	255.0	343.6	80.0	255.0	370.3	-
135.0	75.5	410.0	35.0	255.0	338.9	80.0	255.0	370.3	-
150.0	75.5	410.0	35.0	255.0	336.5	80.0	255.0	359.1	-
165.0	75.0	410.0	35.0	255.0	336.5	80.0	255.0	359.1	-
180.0	75.0	410.0	35.0	255.0	336.5	80.0	255.0	359.1	-
210.0	75.0	410.0	36.0	255.0	334.1	80.0	255.0	352.5	-

Cleaned for 1.5 hours with 2 X MC-3.

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 19-Jan-89

Mode: RBM
Operator: PCF/JRI/PJC

Run Number: 3

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07 Flow Rate (L/min)*	HEM-07 Average pressure (kPa)	HEM-07 Flux Rate (LMH)	HSC-03 Flow Rate (L/min)*	HSC-03 Average pressure (kPa)	HSC-03 Flux Rate (LMH)	% Volume Reduction
0.0	72.5	415.0	37.0	257.5	404.2	80.0	257.5	359.7	0.0
20.0	73.5	415.0	37.0	257.5	384.0	80.0	257.5	338.9	19.5
35.0	75.0	415.0	38.0	257.5	381.6	80.0	257.5	308.0	46.6
50.0	75.5	410.0	38.0	255.0	370.3	80.0	255.0	292.0	66.1
60.0	75.5	415.0	38.0	257.5	359.1	80.0	257.5	269.4	91.4
80.0	72.0	415.0	38.0	257.5	336.5	80.0	257.5	224.3	94.8

Cleaned for 1.25 hours with 2 X MC-3.

*Inaccurate values, see report Section 2.3.2,

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 20-Jan-89

Mode: MBM
Operator: PCF

Run Number: 4

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-03			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
0.0	72.0	415.0	37.0	257.5	269.4	80.0	257.5	341.3	0.0
15.0	73.0	415.0	37.0	257.5	251.1	80.0	257.5	287.3	20.4
30.0	73.0	415.0	37.0	257.5	246.9	80.0	257.5	338.9	33.6
45.0	74.0	410.0	37.0	255.0	233.2	80.0	255.0	321.1	43.2
60.0	75.5	415.0	37.0	257.5	235.6	80.0	257.5	314.6	50.1
75.0	74.0	415.0	37.0	257.5	246.9	80.0	257.5	318.7	55.6
90.0	74.0	415.0	37.0	257.5	237.4	80.0	257.5	309.8	60.0
105.0	74.0	415.0	37.0	257.5	237.4	80.0	257.5	312.2	63.6
120.0	73.5	415.0	37.0	257.5	246.9	80.0	257.5	312.2	66.6
135.0	73.5	415.0	37.0	257.5	225.5	80.0	257.5	305.1	69.1
165.0	75.0	415.0	37.0	257.5	246.9	80.0	257.5	312.2	73.1
195.0	75.0	415.0	37.0	257.5	246.9	80.0	257.5	314.0	76.3
225.0	75.0	415.0	37.0	257.5	225.5	80.0	257.5	325.2	78.8
255.0	75.0	415.0	37.0	257.5	225.5	80.0	257.5	296.8	80.7

Cleaned for 1.5 hours with 4XMC-3.

*Inaccurate values, see report Section 2.3.2.

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 23-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 5

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-03			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
0.0	65.0	415.0	35.0	257.5	224.9	79.0	257.5	300.9	0.0
60.0	72.0	415.0	36.0	257.5	246.9	80.0	257.5	347.8	49.9
75.0	73.5	415.0	36.0	257.5	251.6	80.0	257.5	410.7	56.1
90.0	73.5	415.0	36.0	257.5	251.6	80.0	257.5	404.2	61.1
105.0	75.5	415.0	36.0	257.5	251.6	80.0	257.5	381.6	65.0
135.0	74.0	415.0	37.0	257.5	251.6	80.0	257.5	392.9	70.8
165.0	73.0	415.0	37.0	257.5	246.9	80.0	257.5	359.1	74.9
230.0	73.0	415.0	37.0	257.5	269.4	80.0	257.5	426.7	80.9
290.0	72.0	415.0	38.0	257.5	269.4	80.0	257.5	415.5	84.5
350.0	73.0	415.0	38.0	257.5	269.4	80.0	257.5	403.6	87.0

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 24-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 5

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-03			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
1370.0	71.0	415.0	37.0	257.5	267.1	80.0	257.5	320.5	87.0
1430.0	72.0	415.0	37.0	257.5	269.4	80.0	257.5	327.6	88.5
1445.0	74.0	415.0	37.0	257.5	267.1	80.0	257.5	327.6	88.9
1500.0	74.0	415.0	37.0	257.5	271.8	80.0	257.5	359.1	90.0
1530.0	75.5	415.0	37.0	257.5	280.7	80.0	257.5	359.1	90.5
1600.0	74.0	415.0	37.0	257.5	280.7	80.0	257.5	347.8	91.6
1630.0	75.0	415.0	37.0	257.5	271.8	80.0	257.5	341.3	92.0
1715.0	72.0	415.0	37.0	257.5	269.4	80.0	257.5	336.5	92.8
1745.0	74.0	415.0	37.0	257.5	287.3	80.0	257.5	336.5	93.1
1845.0	75.0	415.0	37.0	257.5	264.1	80.0	257.5	316.3	93.9
1900.0	74.0	415.0	37.0	257.5	260.5	80.0	257.5	314.0	94.2

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 25-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 5

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-03			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
2995.0	73.0	415.0	37.0	257.5	294.4	80.0	257.5	280.7	94.2
3070.0	73.5	415.0	37.0	257.5	292.0	80.0	257.5	283.7	94.6
3130.0	74.0	415.0	37.0	257.5	292.0	80.0	257.5	283.7	94.9
3160.0	70.0	415.0	37.0	257.5	298.5	80.0	257.5	292.0	95.0
3190.0	75.5	415.0	37.0	257.5	309.8	80.0	257.5	292.0	95.1
3250.0	75.0	415.0	37.0	257.5	312.2	80.0	257.5	312.2	95.4
3310.0	75.0	415.0	37.0	257.5	302.7	80.0	257.5	292.0	95.6
3340.0	75.0	415.0	37.0	257.5	292.0	80.0	257.5	280.7	95.7

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 26-Jan-89

Mode: MBM
Operator: PCF

Run Number: 5

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-03			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
4435.0	73.0	415.0	37.0	257.5	292.0	80.0	257.5	273.6	95.7
4450.0	73.0	415.0	37.0	257.5	305.1	80.0	257.5	292.0	95.8
4510.0	74.0	415.0	37.0	257.5	300.9	80.0	257.5	293.8	95.9
4570.0	75.0	415.0	37.0	257.5	292.0	80.0	257.5	280.7	96.1
4600.0	75.5	415.0	37.0	257.5	269.4	80.0	257.5	269.4	96.2
4630.0	73.0	415.0	37.0	257.5	269.4	80.0	257.5	269.4	96.2

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 27-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 5

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-03			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
5875.0	73.0	415.0	37.0	257.5	262.9	80.0	257.5	251.1	96.2
5935.0	73.0	415.0	37.0	257.5	292.0	80.0	257.5	262.9	96.4
5995.0	74.0	415.0	37.0	257.5	287.3	80.0	257.5	404.2	96.5
6055.0	75.0	415.0	37.0	257.5	269.4	80.0	257.5	343.6	96.6
6115.0	75.5	415.0	37.0	257.5	267.1	80.0	257.5	318.7	96.8
6145.0	75.0	415.0	37.0	257.5	246.9	80.0	257.5	325.2	96.8

Cleaned for 2 hours with 4 X MC-3.

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 30-Jan-89

Mode: MBM
Operator: PCF

Run Number: 6

	Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			% Volume Reduction
				Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
	0.0	75.0	415.0	37.0	257.5	292.0	0.0
	15.0	75.0	415.0	37.0	257.5	280.7	11.3
	45.0	75.0	415.0	37.0	257.5	251.1	26.7
	75.0	75.0	415.0	37.0	257.5	246.9	36.9
	135.0	75.5	415.0	37.0	257.5	229.1	50.2
	195.0	75.0	415.0	37.0	257.5	224.9	58.6
	255.0	75.0	415.0	37.0	257.5	201.8	64.2
	315.0	75.0	415.0	37.0	257.5	179.8	68.1
	375.0	75.0	415.0	37.0	257.5	179.8	71.0
31-Jan-89	1380.0	73.0	415.0	38.0	257.5	130.6	87.6
	1440.0	75.0	415.0	38.0	257.5	130.6	88.0
	1500.0	75.0	415.0	38.0	257.5	146.0	88.3
	1560.0	75.0	415.0	38.0	257.5	156.7	88.7
	1620.0	75.0	415.0	38.0	257.5	156.7	89.0
	1680.0	75.0	415.0	38.0	257.5	156.7	89.3
	1740.0	75.0	415.0	38.0	257.5	130.6	89.6
	1800.0	75.0	415.0	38.0	257.5	130.6	89.9
	1830.0	75.0	415.0	38.0	257.5	130.6	90.0

Cleaned for 1.25 hours with 4XMC-3.

*Inaccurate values, see report Section 2.3.2.

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 1-Feb-89

Mode: MBM
Operator: PCF

Run Number: 7

	Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			% Volume Reduction
				Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
	0.0	75.0	415.0	28.0	257.5	314.6	0.0
	30.0	74.0	415.0	28.0	257.5	292.0	21.3
	60.0	72.0	415.0	36.0	257.5	274.2	34.3
	90.0	74.0	415.0	36.0	257.5	269.4	43.3
	120.0	75.5	415.0	36.0	257.5	269.4	50.1
	180.0	74.0	415.0	36.0	257.5	258.2	59.6
	240.0	74.0	415.0	36.0	257.5	246.9	65.8
2-Feb-89	1215.0	73.0	415.0	37.0	257.5	204.2	89.4
	1245.0	73.0	415.0	37.0	257.5	204.2	89.6
	1315.0	73.0	415.0	37.0	257.5	224.9	90.1
	1415.0	72.0	415.0	37.0	257.5	204.2	90.7
	1600.0	75.0	415.0	37.0	257.5	246.9	91.6

Cleaned for 2 hours with 4XMC-3.

*Inaccurate values, see Section 2.3.2.

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 6-Feb-89

Mode: MBM
Operator: PCF

Run
Number: 8

	Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			% Volume Reduction
				Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
	0.0	73.0	415.0	38.0	257.5	298.5	0.0
	15.0	75.0	415.0	38.0	257.5	280.7	11.4
	30.0	75.0	415.0	38.0	257.5	269.4	20.1
	45.0	75.0	415.0	38.0	257.5	260.5	27.0
Stability	75.0	75.5	415.0	38.0	257.5	260.5	37.5
	105.0	75.0	415.0	39.0	257.5	260.5	37.5
RBM	120.0	75.0	415.0	39.0	257.5	260.5	44.7
	135.0	75.0	415.0	39.0	257.5	260.5	52.0
	150.0	75.0	415.0	39.0	257.5	246.9	59.0
	180.0	75.0	415.0	39.0	257.5	246.9	72.8
	210.0	75.0	415.0	39.0	257.5	246.9	86.5
	215.0	75.0	415.0	39.0	257.5	246.9	88.8

Cleaned for 1 hour with MC-3 followed by an overnight soaking.

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*Inaccurate values, see report Section 2.3.2.

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: B
Date: 7-Feb-89

Mode: MBM
Operator: PCF

Run
Number: 9

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
0.0	70.0	415.0	38.0	257.5	258.2	0.0
15.0	71.0	415.0	38.0	257.5	246.9	10.1
30.0	69.0	415.0	38.0	257.5	235.6	18.0
45.0	70.0	415.0	38.0	257.5	235.6	24.5
105.0	75.5	415.0	38.0	257.5	258.2	43.3
120.0	74.0	415.0	38.0	257.5	258.2	46.8
135.0	75.0	415.0	38.0	257.5	258.2	49.8
150.0	75.0	415.0	38.0	257.5	246.9	52.5
180.0	75.0	415.0	38.0	257.5	242.1	57.0
210.0	75.0	415.0	38.0	257.5	244.5	60.6
230.0	75.0	415.0	38.0	257.5	224.9	62.7

Soaked membranes over night in MC-3 and cleaned the following morning for 1 hour.

*Inaccurate values, see Section 2.3.2.

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: B
Date: 8-Feb-89

Mode: MBM
Operator: PCF

Run Number: 10

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
0.0	73.0	415.0	39.0	257.5	235.6	0.0
15.0	75.0	415.0	39.0	257.5	235.6	9.5
45.0	75.0	415.0	39.0	257.5	246.9	24.2
70.0	75.0	415.0	39.0	257.5	246.9	33.5
75.0	75.5	415.0	39.0	257.5	246.9	35.0
90.0	75.0	415.0	39.0	257.5	242.1	39.3
105.0	75.0	415.0	39.0	257.5	242.1	43.0
135.0	75.0	415.0	39.0	257.5	246.9	49.3
165.0	75.0	415.0	39.0	257.5	246.9	54.4
195.0	75.0	415.0	39.0	257.5	242.1	58.5
196.0	75.0	415.0	39.0	257.5	242.1	58.6

Cleaned for 1 hour with MC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 9-Feb-89

Mode: MBM & RBM
Operator: PCF

Run Number: 11

RBM

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
0.0	73.0	415.0	39.0	257.5	169.7	0.0
15.0	73.0	415.0	39.0	257.5	156.7	6.8
45.0	75.0	415.0	39.0	257.5	156.7	17.5
75.0	75.0	415.0	39.0	257.5	156.7	26.0
105.0	75.5	415.0	39.0	257.5	156.7	32.9
120.0	75.0	415.0	39.0	257.5	156.7	37.6
135.0	75.0	415.0	39.0	257.5	156.7	42.3
150.0	75.0	415.0	39.0	257.5	148.4	46.8
180.0	75.0	415.0	39.0	257.5	148.4	55.7
210.0	75.0	415.0	39.0	257.5	148.4	64.5
240.0	75.0	415.0	39.0	257.5	148.4	73.4
270.0	75.0	415.0	39.0	257.5	148.4	82.3
295.0	75.0	415.0	39.0	257.5	148.4	89.6

Cleaned for 2.5 hours with 2XMC-3

$LInaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 25-Jul-89

Mode: MBM
Operator: BM

Run
Number: 12

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07 Flow Rate (L/min)*	HEM-07 Average pressure (kPa)	HEM-07 Flux Rate (LMH)	HST-04 Flow Rate (L/min)*	HST-04 Average pressure (kPa)	HST-04 Flux Rate (LMH)	% Volume Reduction
0.0	72.0	415.0	-	260.0	273.5	-	-		0.0
25.2	73.0	415.0	-	260.0	263.2	-	-		16.7
40.2	73.0	412.0	-	258.5	235.0	-	-		23.7
60.0	73.5	412.0	-	258.5	224.9	-	-		30.9
90.0	72.5	412.0	-	258.5	197.0	-	266.0	285.5	43.2
120.0	73.5	420.0	-	267.5	197.0	-	269.0	252.2	54.0
150.0	73.0	418.0	-	267.5	197.0	-	269.0	241.0	61.1
180.0	73.0	415.0	-	265.0	206.5	-	267.5	232.7	66.2
210.0	73.0	415.0	-	263.5	187.0	-	267.5	219.6	70.0
270.0	73.5	415.0	-	260.0	178.6	-	267.5	178.6	75.1
330.0	73.5	415.0	-	262.5	153.1	-	267.5	164.4	78.3
349.8	72.0	415.0	-	262.5	100.9	-	267.5	131.8	79.1
1354.8	72.0	420.0	-	265.0	107.4	-	270.0	131.8	91.5
1365.0	72.0	415.0	-	260.0	105.6	-	267.5	131.8	91.6
1389.6	73.0	415.0	-	261.5	107.4	-	267.5	142.4	91.7
1420.2	73.0	415.0	-	262.5	107.4	-	267.5	142.4	91.9
1480.2	73.0	415.0	-	262.5	107.4	-	267.5	144.2	92.1
1540.2	73.0	415.0	-	262.5	109.8	-	267.5	147.2	92.4
1600.2	73.0	415.0	-	262.5	112.2	-	267.5	153.7	92.7
1660.2	72.5	415.0	-	262.5	112.2	-	267.5	153.7	92.9
1720.2	72.0	415.0	-	262.5	112.2	-	267.5	153.7	93.2
1780.2	72.0	415.0	-	262.5	109.8	-	267.5	142.4	93.4
2790.0	72.5	415.0	-	267.5	112.2	-	267.5	151.3	95.6
2850.0	72.5	415.0	-	260.0	107.4	-	267.5	151.3	95.7
2910.0	72.5	415.0	-	260.0	107.4	-	267.5	149.0	95.8
2970.0	72.5	415.0	-	260.0	109.8	-	267.5	136.5	95.9
3030.0	72.5	415.0	-	260.0	112.2	-	267.5	137.7	95.9
3090.0	72.5	415.0	-	260.0	109.8	-	267.5	136.5	96.0

*Inaccurate values, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 25-Jul-89

Mode: MBM
Operator: BM

Run Number: 12

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07 Flow Rate (L/min)*	HEM-07 Average pressure (kPa)	HEM-07 Flux Rate (LMH)	HST-04 Flow Rate (L/min)*	HST-04 Average pressure (kPa)	HST-04 Flux Rate (LMH)	% Volume Reduction
3150.0	72.5	415.0	-	260.0	109.8	-	267.5	137.7	96.0
3198.0	72.5	415.0	-	260.0	98.5	-	267.5	137.7	96.1
4215.0	72.5	415.0	-	260.0	87.2	-	267.5	131.8	96.9
4240.2	72.5	415.0	-	260.0	87.2	-	271.5	131.8	96.9

Cleaned for 2 hours with 4XMC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCEI PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 28-Jul-89

Mode: Stability
Operator: BM

Run
Number: 13

Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HST-04			% Volume Reduction
			Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
0.0	71	415.0	-	260.0	224.9	-	260.0	274.2	0.0
13.2	71.5	415.0	-	260.0	151.3	-	260.0	204.2	0.0
28.2	72	415.0	-	260.0	134.1	-	260.0	187.0	0.0
43.2	72	415.0	-	260.0	129.4	-	260.0	184.6	0.0
58.2	72	415.0	-	260.0	123.4	-	260.0	173.3	0.0
163.2	72	415.0	-	265.0	100.9	-	260.0	179.8	0.0
343.2	73	415.0	-	270.0	89.6	-	260.0	146.0	0.0
523.2	73	415.0	-	262.5	85.5	-	260.0	123.4	0.0
703.2	73	420.0	-	270.0	78.9	-	262.5	123.4	0.0
943.2	73	420.0	-	270.0	67.1	-	262.5	112.2	0.0
1243.2	72	420.0	-	271.5	69.4	-	264.0	112.2	0.0
1423.2	73	420.0	-	270.0	67.1	-	264.0	112.2	0.0
1603.2	72	420.0	-	270.0	67.1	-	264.0	108.0	0.0
1783.2	73	420.0	-	270.0	67.1	-	264.0	105.6	0.0
1963.2	73	420.0	-	270.0	67.1	-	262.5	100.9	0.0
2143.2	73	420.0	-	270.0	67.1	-	262.5	100.9	0.0
2443.2	69	420.0	-	270.0	67.1	-	262.5	100.9	0.0
2683.2	73	415.0	-	269.0	67.1	-	261.5	94.4	0.0
2863.2	73	420.0	-	271.5	67.1	-	264.0	94.4	0.0
3043.2	73	420.0	-	271.5	67.1	-	263.5	94.4	0.0
3223.2	73	420.0	-	271.5	61.1	-	264.0	89.6	0.0
3403.2	73	420.0	-	271.0	62.9	-	264.0	89.6	0.0
3583.2	73	420.0	-	272.5	62.9	-	262.5	89.6	0.0
3823.2	73	420.0	-	272.5	62.9	-	262.5	89.6	0.0
4063.2	73	415.0	-	260.0	55.2	-	260.0	86.1	0.0

Cleaned for 1.5 hours with 4XMC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 31-Jul-89

Mode: MBM
Operator: BM

Run Number: 14

	Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HEM-08			% Volume Reduction
				Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
	0	72.0	415	-	260	269.4	-	260	296.8	0.0
	15	72.0	415	-	260	236.2	-	260	246.9	18.9
	30	72.0	415	-	260	231.5	-	260	231.5	30.7
	45	72.0	415	-	260	220.2	-	260	224.9	39.2
	60	72.0	415	-	260	204.8	-	260	224.9	45.7
1-Aug-89	990	72.0	415	-	260	153.7	-	260	246.9	92.5
	990	63	415	-	260	153.7	-	260	246.9	92.5
	1005	70	415	-	260	143.6	-	260	242.7	92.6
	1020	73	415	-	260	143.6	-	260	232.1	92.7
	1035	73	415	-	260	138.9	-	260	226.7	92.8
	1050	72	415	-	260	135.3	-	260	224.9	92.8
	1080	72	415	-	260	130.6	-	260	207.1	93.0
	1110	72	415	-	260	125.8	-	260	204.8	93.1
	1140	72	415	-	260	118.7	-	260	200.0	93.3
	1170	72	415	-	260	116.9	-	260	200.0	93.4
	1200	72	415	-	260	114.5	-	260	197.6	93.5
	1260	72	415	-	260	114.5	-	260	192.3	93.7
	1320	72	415	-	260	114.0	-	260	188.7	93.9
	1350	72	415	-	260	112.2	-	260	184.6	94.0
	1380	72	415	-	260	109.8	-	260	182.2	94.1
2-Aug-89	2400	71	415	-	260	100.9	-	260	179.8	96.1
	2430	69	415	-	260	103.3	-	260	179.8	96.1
	2490	71	415	-	260	110.4	-	260	179.8	96.2
	2550	71	415	-	260	108.0	-	260	179.8	96.3
	2610	72	415	-	260	108.0	-	260	179.8	96.4
	2670	72	415	-	260	101.5	-	260	177.5	96.4
	2730	72	415	-	260	94.4	-	260	162.0	96.5
	2790	72	415	-	260	94.4	-	260	159.7	96.5

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 31-Jul-89

Mode: MBM
Operator: BM

Run
Number: 14

	Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HEM-08			% Volume Reduction
				Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
Stability	2790	72.5	415	-	260	89.6	-	260	157.3	96.5
3-Aug-89	3830	72.5	415	-	260	89.6	-	260	159.7	94.2
MBM	3850	72.5	415	-	260	92.0	-	260	175.1	94.3
	3875	72.5	415	-	260	92.0	-	260	168.6	94.3
	3915	72.5	415	-	260	87.8	-	260	175.1	94.4
	3975	72.5	415	-	260	78.3	-	260	139.5	94.6
	4035	72.5	415	-	260	78.3	-	260	139.5	94.7
	4095	72.5	415	-	260	80.7	-	260	134.7	94.8
	4155	72.5	415	-	260	83.1	-	260	140.7	94.9
	4215	72.5	415	-	260	74.2	-	260	134.7	95.0
	4275	71	415	-	260	69.4	-	260	132.4	95.1
	4335	71.5	415	-	260	67.7	-	260	132.4	95.2
	4395	72	415	-	260	69.4	-	260	123.4	95.2
	4455	72	415	-	260	67.7	-	260	123.4	95.3
Stability	4500	72	415	-	260	65.3	-	260	116.9	95.4
4-Aug-89	5235	72	415	-	260	65.3	-	260	116.9	95.4

Cleaned for 2 hours with 4XMC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 4-Aug-89

Mode: Stability
Operator: BM

Run
Number: 15

	Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07 Flow Rate (L/min)*	HEM-07 Average pressure (kPa)	HEM-07 Flux Rate (LMH)	HEM-08 Flow Rate (L/min)*	HEM-08 Average pressure (kPa)	HEM-08 Flux Rate (LMH)	% Volume Reduction
	0.0	73.0	415.0	-	260.0	258.2	-	260.0	268.3	0.0
	15.0	73.0	415.0	-	260.0	224.9	-	260.0	245.1	0.0
	30.0	72.5	415.0	-	260.0	213.7	-	260.0	213.7	0.0
	45.0	72.0	415.0	-	260.0	193.5	-	260.0	201.8	0.0
	60.0	72.0	415.0	-	260.0	182.2	-	260.0	197.6	0.0
	90.0	72.0	415.0	-	260.0	179.8	-	260.0	191.1	0.0
	120.0	72.0	415.0	-	260.0	170.9	-	260.0	177.5	0.0
	150.0	72.0	415.0	-	260.0	157.3	-	260.0	157.3	0.0
	169.8	72.0	415.0	-	260.0	134.7	-	260.0	152.5	0.0
	244.8	71.5	410.0	-	260.0	134.7	-	260.0	134.7	0.0
	424.8	72.0	410.0	-	260.0	134.7	-	260.0	146.0	0.0
	604.8	72.0	410.0	-	255.0	123.4	-	260.0	134.7	0.0
5-Aug-89	784.8	72.0	410.0	-	255.0	123.4	-	260.0	134.7	0.0
	964.8	72.0	410.0	-	255.0	123.4	-	260.0	134.7	0.0
	1144.8	72.0	410.0	-	255.0	112.2	-	260.0	134.7	0.0
	1324.8	72.0	410.0	-	257.5	112.2	-	257.5	123.4	0.0
	1504.8	72.0	410.0	-	260.0	89.6	-	257.5	100.9	0.0
	1684.8	67.0	415.0	-	262.5	89.6	-	260.0	100.9	0.0
	1864.8	72.0	410.0	-	257.5	78.3	-	260.0	89.6	0.0
	2044.8	73.0	410.0	-	257.5	56.4	-	260.0	78.3	0.0
6-Aug-89	2224.8	73.0	410.0	-	260.0	56.4	-	260.0	71.8	0.0
	2404.8	73.0	410.0	-	260.0	56.4	-	260.0	67.7	0.0
	2764.8	72.0	410.0	-	257.5	45.1	-	257.5	67.7	0.0
	2944.8	72.5	410.0	-	257.5	45.1	-	257.5	67.7	0.0
	3124.8	72.5	410.0	-	257.5	45.1	-	257.5	67.7	0.0
	3304.8	72.5	415.0	-	262.5	45.1	-	260.0	67.7	0.0
	3484.8	72.5	415.0	-	262.5	33.8	-	260.0	60.5	0.0
7-Aug-89	3664.8	72.5	415.0	-	262.5	33.8	-	260.0	56.4	0.0

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 4-Aug-89

Mode: Stability
Operator: BM

Run
Number: 15

	Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07				HEM-08		% Volume Reduction
				Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
	3844.8	72	415.0	-	262.5	33.8	-	260.0	56.4	0.0
	4024.8	72	415.0	-	262.5	33.8	-	260.0	56.4	0.0
	4924.8	72	410.0	-	260.0	33.8	-	257.5	45.1	0.0
8-Aug-89	5104.8	73	410.0	-	260.0	33.8	-	257.5	45.1	0.0
	5284.8	73	410.0	-	260.0	33.8	-	257.5	45.1	0.0
	5464.8	73	410.0	-	260.0	40.4	-	257.5	45.1	0.0
	5589.6	73	415.0	-	260.0	40.4	-	260.0	45.1	0.0

Cleaned for 2 hours with 4XMC-3

*Inaccurate values, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 9-Aug-89

Mode: MBM
Operator: BM

Run
Number: 16

	Elapsed Time (min)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07				HST-04		% Volume Reduction
				Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average pressure (kPa)	Flux Rate (LMH)	
	5.0	72.0	420.0	-	262.5	318.7	-	262.5	392.9	0.0
	15.0	72.0	420.0	-	262.5	303.3	-	262.5	381.6	17.2
	30.0	72.0	420.0	-	262.5	269.4	-	262.5	337.1	33.1
	45.0	72.0	420.0	-	262.5	258.2	-	262.5	337.1	43.3
	60.0	72.0	420.0	-	262.5	246.9	-	262.5	325.8	50.5
	75.0	72.0	420.0	-	262.5	249.3	-	262.5	325.8	56.1
Stability MBM	85.2	72.0	420.0	-	262.5	246.9	-	262.5	314.6	59.2
	1080.0	72.0	420.0	-	262.5	197.6	-	262.5	269.4	59.2
	1095.0	72.0	420.0	-	262.5	184.0	-	262.5	213.7	62.1
	1110.0	72.0	420.0	-	262.5	188.7	-	262.5	233.2	64.6
	1140.0	72.0	420.0	-	262.5	184.0	-	262.5	235.6	68.7
	1200.0	72.0	420.0	-	262.5	182.2	-	262.5	213.7	74.5
	1260.0	72.0	420.0	-	262.5	179.8	-	262.5	213.7	78.4
	1320.0	72.0	420.0	-	262.5	179.8	-	262.5	211.3	81.2
	1380.0	73.0	420.0	-	262.5	168.6	-	262.5	202.4	83.3
	1440.0	72.0	420.0	-	262.5	168.6	-	262.5	200.0	85.0
	1500.0	72.0	420.0	-	262.5	166.8	-	262.5	200.0	86.3
Stability MBM	1510.2	72.0	420.0	-	262.5	166.8	-	262.5	200.0	86.5
	2509.8	73.0	420.0	-	262.5	179.8	-	262.5	202.4	86.5
	2520.0	73.0	420.0	-	262.5	177.5	-	262.5	202.4	86.7
	2550.0	73.0	420.0	-	262.5	175.1	-	262.5	200.0	87.3
	2580.0	73.0	420.0	-	262.5	162.0	-	262.5	197.6	87.8
	2640.0	73.0	420.0	-	262.5	162.0	-	262.5	197.6	88.7
	2700.0	73.0	420.0	-	262.5	157.3	-	262.5	197.6	89.5
	2760.0	71.0	420.0	-	262.5	157.3	-	262.5	184.0	90.1
	2820.0	72.0	420.0	-	262.5	161.4	-	262.5	197.6	90.7
	2850.0	72.0	420.0	-	262.5	157.3	-	262.5	191.1	90.9

Cleaned for 2 hours with 4XMC-3

*Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 23-Oct-89

Mode: FBM
Operator: BM

Run
Number: 17

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07 Flow Rate (L/min)*	HEM-07 Average Pressure (kPa)	HEM-07 Flux Rate (LMH)	HST-07 Flow Rate (L/min)*	HST-07 Average Pressure (kPa)	HST-07 Flux Rate (LMH)	Conc. Bleed Rate (L/min)	Volume Reduction (%)
0.0	73.0	415	-	-	-	-	260.0	413.1	0	0.0
0.3	71.5	415	-	-	-	-	260.0	249.3	0	12.9
1.0	72.5	415	-	-	-	-	260.0	141.3	0	29.1
1.5	73.0	415	-	-	-	-	260.0	121.1	0	34.5
2.0	73.0	415	-	-	-	-	260.0	104.5	0	38.6
3.0	73.0	415	-	-	-	-	260.0	93.8	0	44.6
4.0	73.0	415	-	-	-	-	260.0	95.0	0	49.4
5.0	74.0	415	-	-	-	-	260.0	79.5	0	53.1
6.0	72.5	415	-	-	-	-	260.0	71.2	0	55.9
23.0	73.0	415	-	-	-	-	260.0	57.0	0	76.3
24.0	73.0	415	-	-	-	-	260.0	58.2	0	76.8
24.5	73.0	415	-	260.0	227.9	-	260.0	57.6	0	77.6
25.0	73.0	415	-	260.0	125.8	-	260.0	48.1	0	78.6
26.0	73.0	415	-	260.0	83.1	-	260.0	43.3	0	79.8
30.0	73.0	415	-	260.0	56.4	-	260.0	36.8	0	82.6
46.5	73.0	415	-	260.0	40.1	-	260.0	35.0	0	87.8
48.0	73.0	415	-	260.0	39.8	-	260.0	35.0	0	88.1
49.0	73.0	415	-	260.0	39.2	-	260.0	34.4	0	88.3
51.0	73.0	415	-	260.0	39.8	-	260.0	35.3	0	88.7
53.5	73.0	415	-	260.0	39.8	-	260.0	35.0	0	89.1

Cleaned for 2 hours with 4XMC-3.

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* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 25-Oct-89

Mode: FBM
Operator: BM

Run Number: 18

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HST-04			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
0.0	74.0	415	-	260.0	385.8	-	260.0	569.8	0	0.0
0.5	72.5	415	-	260.0	311.0	-	260.0	415.5	0	42.9
2.5	74.5	415	-	260.0	256.4	-	260.0	330.0	0	75.6
14.8	72.0	415	-	260.0	132.9	-	260.0	159.1	0	93.0
16.0	74.0	415	-	260.0	118.7	-	260.0	154.3	0.335	93.2
17.0	74.0	415	-	260.0	115.7	-	260.0	150.7	0.335	93.1
18.0	73.0	415	-	260.0	113.4	-	260.0	147.2	0.335	92.9
19.0	73.0	415	-	260.0	115.7	-	260.0	144.8	0.335	92.9
20.3	73.0	415	-	260.0	108.0	-	260.0	138.3	0.335	92.5
21.5	73.0	415	-	260.0	105.6	-	260.0	131.8	0.335	92.3
38.5	73.0	415	-	260.0	78.3	-	260.0	96.7	0.335	89.8
39.0	73.0	415	-	260.0	76.6	-	260.0	98.5	0.335	89.8
40.0	73.0	415	-	260.0	74.8	-	260.0	96.1	0.335	89.6
41.0	73.0	415	-	260.0	72.4	-	260.0	96.1	0.335	89.4
42.0	73.0	415	-	260.0	68.8	-	260.0	89.0	0.335	88.8
43.0	73.0	415	-	260.0	67.7	-	260.0	87.8	0.246	91.4
46.0	73.0	415.0	-	262.5	59.4	-	262.5	77.2	0.246	90.3
48.3	72.0	415.0	-	262.5	54.6	-	262.5	70.6	0.246	89.6
75.0	71.0	420.0	-	260.0	37.4	-	260.0	50.4	0.246	85.7
78.3	75.0	420.0	-	262.5	41.0	-	262.5	53.4	0.246	86.6
81.3	75.0	420.0	-	262.5	39.2	-	262.5	51.0	0.246	86.1
83.3	74.0	420.0	-	262.5	38.6	-	262.5	49.3	0.246	85.7
87.3	74.0	420.0	-	265.0	37.4	-	265.0	47.5	0.246	85.3
90.3	73.0	420.0	-	265.0	35.6	-	265.0	46.3	0.246	84.9
93.6	74.0	420.0	-	265.0	33.8	-	265.0	43.9	0.246	84.2
96.3	74.0	420.0	-	267.5	33.2	-	267.5	43.9	0.246	84.1

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 25-Oct-89

Mode: FBM
Operator: BM

Run Number 18

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HST-04			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
99.3	74.0	425	-	270.0	31.8	-	270.0	39.2	0.246	82.9
102.3	74.0	425	-	270.0	33.2	-	270.0	43.3	0.246	84.0
105.3	75.0	425	-	270.0	32.6	-	270.0	43.3	0.246	83.9
108.3	74.0	415	-	260.0	34.4	-	260.0	42.7	0.133	90.7
109.3	74.0	415	-	260.0	30.9	-	260.0	42.1	0.133	90.2
110.3	73.0	415	-	260.0	31.5	-	260.0	43.9	0.133	90.5
111.3	73.0	415	-	260.0	32.0	-	260.0	42.7	0.133	90.5
112.3	73.0	415	-	260.0	32.6	-	260.0	43.0	0.133	90.6
113.3	73.0	415	-	260.0	32.6	-	260.0	41.5	0.133	90.4
114.3	73.0	415	-	260.0	32.6	-	260.0	42.7	0.133	90.5
115.5	73.0	415	-	260.0	32.6	-	260.0	42.7	0.133	90.5
132.3	73.0	415	-	260.0	32.6	-	260.0	42.7	0.133	90.5
133.3	73.0	415	-	260.0	32.6	-	260.0	42.7	0.133	90.5
134.3	73.0	415	-	260.0	32.0	-	260.0	41.5	0.133	90.3
135.3	73.0	415	-	260.0	32.0	-	260.0	42.1	0.133	90.4
136.3	73.0	415	-	260.0	32.6	-	260.0	42.1	0.133	90.5
137.3	73.0	415	-	260.0	32.0	-	260.0	42.1	0.133	90.4
138.3	73.0	415	-	260.0	32.0	-	260.0	42.1	0.133	90.4
139.3	73.0	415	-	260.0	33.2	-	260.0	42.1	0.133	90.5
155.9	73.0	415	-	260.0	33.2	-	260.0	44.5	0.133	90.8

Cleaned for 2 hours with 4XMC-3.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 1-Nov-89

Mode: FBM
Operator: BM

Run
Number: 19

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HST-04			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
0.1	73.0	415	-	260.0	341.9	-	260.0	413.1	0	0.0
0.3	73.0	415	-	260.0	299.1	-	260.0	377.5	0	17.6
0.5	73.0	415	-	260.0	284.9	-	260.0	356.1	0	33.7
0.8	73.0	415	-	260.0	278.9	-	260.0	345.4	0	44.2
1.0	73.0	415	-	260.0	267.1	-	260.0	336.5	0	51.6
2.0	73.0	415	-	260.0	260.0	-	260.0	313.4	0	67.9
3.0	73.0	415	-	260.0	235.0	-	260.0	299.1	0	75.7
4.0	73.0	415	-	260.0	216.0	-	260.0	270.6	0	80.1
4.8	73.0	415	-	260.0	173.3	-	260.0	225.5	0.81	89.2
21.5	78.0	415	-	260.0	166.2	-	260.0	206.5	0.81	88.6
22.5	74.0	415	-	260.0	138.9	-	260.0	175.7	0.67	88.8
23.5	74.0	415	-	260.0	136.5	-	260.0	169.7	0.67	88.5
24.5	51.0	390	-	245.0	80.7	-	245.0	98.5	0.67	81.8
24.8	58.0	415	-	260.0	89.0	-	260.0	116.3	0.67	83.8
25.0	60.0	415	-	260.0	89.0	-	260.0	112.8	0.67	83.5
25.3	63.0	415	-	260.0	92.6	-	260.0	115.1	0.67	83.9
25.5	70.0	415.0	-	262.5	104.5	-	262.5	130.6	0.67	85.5
26.3	79.0	415.0	-	262.5	119.3	-	262.5	148.4	0.67	87.1
27.3	72.0	420.0	-	260.0	95.0	-	260.0	114.0	0.67	84.0
28.4	73.0	420.0	-	262.5	87.8	-	262.5	108.0	0.36	90.2
28.9	72.0	420.0	-	262.5	86.1	-	262.5	106.2	0.36	90.0
36.0	70.0	420.0	-	262.5	58.8	-	262.5	68.8	0.36	85.7
36.5	74.0	420.0	-	265.0	59.4	-	265.0	71.8	0.36	86.0
37.0	73.0	420.0	-	265.0	58.2	-	265.0	69.4	0.36	85.7
37.5	73.0	420.0	-	265.0	54.6	-	265.0	67.1	0.288	87.7
38.0	73.0	420.0	-	267.5	53.4	-	267.5	65.9	0.196	91.1

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 1-Nov-89

Mode: FBM
Operator: BM

Run Number: 19

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HST-04			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
38.5	73.0	425	-	270.0	52.2	-	270.0	63.5	0.196	90.9
39.0	73.0	425	-	270.0	51.6	-	270.0	63.5	0.196	90.8
39.5	73.0	425	-	270.0	50.4	-	270.0	62.3	0.196	90.6
40.0	73.0	415	-	260.0	51.0	-	260.0	61.7	0.196	90.6
40.5	73.0	415	-	260.0	49.9	-	260.0	61.7	0.196	90.6
41.0	73.0	415	-	260.0	49.3	-	260.0	59.9	0.196	90.4
43.5	73.0	415	-	260.0	45.7	-	260.0	54.6	0.196	89.6
46.5	73.0	415	-	260.0	43.9	-	260.0	51.0	0.196	89.1
50.5	73.0	410	-	257.5	38.0	-	257.5	44.5	0.196	87.6
53.5	73.0	410	-	256.5	35.6	-	256.5	43.9	0.196	87.2
57.5	73.0	410	-	256.0	33.2	-	256.0	42.7	0.196	86.7
61.5	73.0	415	-	260.0	32.0	-	260.0	38.0	0.196	85.8
64.5	73.0	415	-	260.0	31.5	-	260.0	37.4	0.196	85.5
67.5	73.0	415	-	260.0	32.6	-	260.0	38.0	0.196	85.9
70.5	73.0	415	-	260.0	31.5	-	260.0	38.6	0.196	85.8
74.5	73.0	415	-	260.0	30.9	-	260.0	37.4	0.196	85.4
77.5	73.0	420	-	262.5	30.9	-	262.5	38.0	0.196	85.5
80.5	73.0	420	-	261.0	30.3	-	261.0	36.8	0.196	85.2
85.5	73.0	420	-	262.5	29.7	-	262.5	39.2	0.196	85.5
88.5	73.0	420	-	261.0	28.5	-	261.0	38.0	0.196	85.1
91.5	73.0	410	-	256.0	28.5	-	256.0	39.2	0.196	85.3
92.5	73.0	415	-	258.5	29.7	-	258.5	38.0	0.196	85.3
97.5	73.0	410	-	257.5	29.7	-	257.5	37.4	0.196	85.2
106.8	73.0	415	-	260.0	30.3	-	260.0	40.4	0.196	85.9
107.8	74.0	415	-	260.0	30.3	-	260.0	41.5	0.1358	89.9
108.8	74.0	415	-	260.0	30.3	-	260.0	42.1	0.1358	90.0

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 1-Nov-89

Mode: FBM
Operator: BM

Run Number: 19

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07 Flow Rate (L/min)*	HEM-07 Average Pressure (kPa)	HEM-07 Flux Rate (LMH)	HST-04 Flow Rate (L/min)*	HST-04 Average Pressure (kPa)	HST-04 Flux Rate (LMH)	Conc. Bleed Rate (L/min)	Volume Reduction (%)
109.8	73.0	415	-	260.0	30.3	-	260.0	41.5	0.1358	89.9
110.8	73.0	415	-	260.0	29.7	-	260.0	40.4	0.1358	89.7
111.8	73.0	415	-	260.0	29.7	-	260.0	40.1	0.1358	89.6
112.8	73.0	415	-	260.0	28.5	-	260.0	38.6	0.1358	89.3
113.8	73.0	415	-	260.0	27.3	-	260.0	36.8	0.1358	88.8
115.3	73.0	415	-	260.0	26.7	-	260.0	35.6	0.1358	88.5
130.8	73.0	415	-	260.0	23.7	-	260.0	32.0	0.1358	87.4
131.8	73.0	415	-	260.0	23.7	-	260.0	32.6	0.1358	87.5
132.8	73.0	415	-	260.0	23.1	-	260.0	32.0	0.1358	87.3
133.8	73.0	415	-	260.0	22.6	-	260.0	32.0	0.1358	87.1
134.8	73.0	415	-	260.0	22.6	-	260.0	32.0	0.1358	87.1
135.8	74.0	415	-	260.0	22.6	-	260.0	32.0	0.1358	87.1
136.8	73.0	415	-	260.0	22.6	-	260.0	32.0	0.1358	87.1
137.8	73.0	415	-	260.0	22.6	-	260.0	32.0	0.1358	87.1
154.8	73.0	415	-	260.0	19.0	-	260.0	24.9	0.1358	84.5

Cleaned for 2 hours with 4XMC-3. System then preserved in MP-1 because of pump failure.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 20-Nov-89

Mode: FBM
Operator: BM

Run Number: 20

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-04			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
0.1	73.0	415	-	260.0	279.5	-	260.0	605.4	0	0
0.3	73.0	415	-	260.0	225.5	-	260.0	474.8	0	27
0.5	73.0	415	-	260.0	198.2	-	260.0	474.8	0	40
0.8	73.0	415	-	260.0	191.1	-	260.0	465.3	0	49
0.0	72.0	415	-	260.0	173.3	-	260.0	436.8	0	11
1.5	74.0	415	-	260.0	172.1	-	260.0	415.5	0	63
2.0	73.0	415	-	260.0	156.7	-	260.0	356.1	0	69
2.5	73.0	415	-	260.0	155.5	-	260.0	358.5	0	73
3.0	73.0	415	-	260.0	147.2	-	260.0	338.3	0	76
3.5	73.0	415	-	260.0	146.6	-	260.0	336.5	0	78
4.0	73.0	415	-	260.0	135.3	-	260.0	324.1	0	80
4.5	73.0	415	-	260.0	134.1	-	260.0	322.3	0.88	90
19.5	73.0	415	-	260.0	89.0	-	260.0	201.8	0.88	85
20.5	73.0	415	-	260.0	87.2	-	260.0	204.2	0.55	90
21.5	73.0	415	-	260.0	86.7	-	260.0	195.9	0.55	90
22.5	73.0	415	-	260.0	86.7	-	260.0	198.2	0.55	90
23.5	73.0	415	-	260.0	86.7	-	260.0	197.0	0.55	90
24.5	73.0	415	-	260.0	85.5	-	260.0	192.3	0.55	89
25.5	73.0	415	-	260.0	81.9	-	260.0	180.4	0.23	95
26.5	73.0	415	-	260.0	80.7	-	260.0	181.6	0.23	95
27.5	73.0	415	-	260.0	86.7	-	260.0	180.4	0.23	95.1
28.5	73.0	415	-	260.0	83.1	-	260.0	178.1	0.23	95.0
43.5	75.0	415.0	-	260.0	71.2	-	260.0	168.6	0.23	94.6
44.5	73.0	415.0	-	260.0	66.5	-	260.0	150.2	0.23	94.1
45.5	73.0	415.0	-	260.0	67.7	-	260.0	151.9	0.191	95.1
46.5	73.0	415.0	-	260.0	67.7	-	260.0	150.2	0.191	95.1

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 20-Nov-89

Mode: FBM
Operator: BM

Run
Number: 20

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HSC-04			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
47.5	73.0	415	-	265.0	68.8	-	265.0	153.7	0.191	95.2
48.5	73.0	415	-	260.0	68.8	-	260.0	151.9	0.191	95.1
49.5	73.0	415	-	260.0	70.0	-	260.0	156.7	0.191	95.2
50.5	73.0	415	-	260.0	70.0	-	260.0	156.7	0.191	95.2
51.5	73.0	415	-	260.0	70.0	-	260.0	156.7	0.191	95.2
68.3	75.0	415	-	262.5	83.1	-	262.5	185.2	0.191	95.9
69.0	73.0	415	-	260.0	83.1	-	260.0	169.7	0.191	95.7
70.0	73.0	415	-	260.0	80.1	-	260.0	169.7	0.191	95.7
71.0	73.0	415	-	260.0	79.5	-	260.0	170.9	0.191	95.7
72.0	73.0	415	-	260.0	78.9	-	260.0	168.6	0.191	95.6
73.0	73.0	415	-	260.0	79.5	-	260.0	167.4	0.191	95.6
74.0	73.0	415	-	260.0	80.7	-	260.0	167.4	0.191	95.6
75.0	74.0	415	-	260.0	80.7	-	260.0	170.9	0.191	95.7
76.0	73.0	415	-	260.0	80.7	-	260.0	167.4	0.191	95.6
99.2	77.0	415	-	260.0	95.0	-	260.0	181.6	0.191	96.1
99.3	73.0	415	-	260.0	99.7	-	260.0	168.6	0.191	95.9
99.5	72.0	415	-	260.0	90.2	-	260.0	163.8	0.191	95.7

Cleaned for 2 hours with 4XMC-3.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 27-Nov-89

Mode: FBM
Operator: DJ

Run Number: 21

			HSC-04			HEM-07				
Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Conc. Bleed Rate (L/min)	Volume Reduction (%)
0.0	70.0	415	-	260.0	311.6	-	260.0	260.0	-	0
0.3	72.0	415	-	260.0	210.1	-	260.0	192.3	-	18
0.5	72.0	415	-	260.0	167.4	-	260.0	163.8	-	28
1.0	72.0	415	-	260.0	137.7	-	260.0	142.4	-	40
1.5	72.0	415	-	260.0	124.6	-	260.0	130.6	-	47
2.0	72.0	415	-	260.0	114.0	-	260.0	121.1	-	53
2.5	72.0	415	-	260.0	106.2	-	260.0	114.0	-	57
3.5	72.0	415	-	260.0	102.1	-	260.0	110.4	-	63
4.5	72.0	415	-	260.0	89.0	-	260.0	102.1	-	67
5.5	72.0	415	-	260.0	81.9	-	260.0	96.1	-	71
6.3	72.0	415	-	260.0	78.3	-	260.0	95.0	-	72
23.0	76.0	415	-	260.0	43.9	-	260.0	68.3	-	88
23.3	72.0	415	-	260.0	41.0	-	260.0	62.9	-	88
24.0	72.0	415	-	260.0	41.5	-	260.0	66.5	-	88
25.3	71.0	415	-	260.0	38.6	-	260.0	62.9	-	88
26.0	72.0	415	-	260.0	39.2	-	260.0	64.1	-	88
27.0	72.0	415	-	260.0	38.0	-	260.0	62.9	-	89
28.3	72.0	415	-	260.0	36.8	-	260.0	61.7	[illegible]	89
29.0	72.0	415	-	260.0	36.2	-	260.0	60.5	-	89
30.0	73.0	415	-	260.0	34.4	-	260.0	59.9	-	89
31.0	73.0	415	-	260.0	35.6	-	260.0	59.4	-	89
0.0	0.0		-	0.0	0.0	-	0.0	0.0	0	0
0.0	0.0		-	0.0	0.0	-	0.0	0.0	0	0
0.0	0.0		-	0.0	0.0	-	0.0	0.0	0	0

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: Nov 28, 29/89

Mode: FBM
Operator: DJ

Run Number: 21

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HSC-04 Flow Rate (L/min)*	HSC-04 Average Pressure (kPa)	HSC-04 Flux Rate (LMH)	HEM-07 Flow Rate (L/min)*	HEM-07 Average Pressure (kPa)	HEM-07 Flux Rate (LMH)	Conc. Bleed Rate (L/min)	Volume Reduction (%)
47.3	73.0	380	-	240.0	21.4	-	240.0	46.3	-	91
47.3	73.0	415	-	260.0	24.9	-	260.0	51.0	-	91
48.0	72.0	415	-	260.0	24.3	-	260.0	48.1	-	91
49.0	73.0	415	-	260.0	24.3	-	260.0	49.3	-	92
50.0	72.0	415	-	260.0	23.1	-	260.0	48.1	-	92
51.0	72.0	415	-	260.0	23.7	-	260.0	48.7	-	92
52.0	72.0	415	-	260.0	22.6	-	260.0	47.5	-	92
53.0	72.0	415	-	260.0	23.1	-	260.0	46.9	-	92
54.0	72.0	415	-	260.0	21.4	-	260.0	45.7	-	92
55.0	72.0	375	-	232.5	19.0	-	232.5	42.7	-	92
71.5	73.0	415	-	252.5	16.0	-	252.5	39.2	-	93
71.8	73.0	415	-	260.0	18.4	-	260.0	42.7	-	93
72.8	72.0	415	-	260.0	18.4	-	260.0	42.7	-	93
73.5	72.0	415	-	260.0	18.4	-	260.0	42.1	-	93
75.8	72.0	415	-	260.0	17.8	-	260.0	41.5	-	93
76.0	70.0	415	-	260.0	135.3	-	260.0	180.4	-	93
76.3	71.0	415	-	260.0	108.6	-	260.0	154.9	-	93
76.5	72.0	415	-	260.0	101.5	-	260.0	147.8	-	93
76.8	73.0	375	-	232.5	80.1	-	232.5	122.9	-	93
77.0	72.0	375	-	232.5	73.0	-	232.5	115.7	0.177	
81.0	76.0	375	-	232.5	49.9	-	232.5	87.8	0.12	

Cleaned for 2 hours with 4XMC-3.

ZENON ENVIRONMENTAL INC.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: Nov 30, Dec 1/89

Mode: FBM
Operator: DJ

Run Number: 22

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HSC-04			HEM-07			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
0.0	72.0	375	-	237.5	29.7	-	237.5	65.3	0.12	93
0.25	73.0	415	-	260.0	34.4	-	260.0	76.0	0.098	95
1.25	74.0	415	-	260.0	33.2	-	260.0	73.6	0.098	95
2.25	72.0	415	-	260.0	30.9	-	260.0	70.0	0.098	95
3.25	73.0	415	-	260.0	30.9	-	260.0	70.0	0.0895	95
4.25	74.0	415	-	260.0	31.5	-	260.0	68.8	0.0895	95
5.25	74.0	415	-	260.0	31.5	-	260.0	68.8	0.0895	95
6.25	73.0	415	-	260.0	27.9	-	260.0	65.9	0.0895	95
7.25	73.0	415	-	260.0	27.3	-	260.0	65.3	0.0895	95
8.25	72.0	415	-	260.0	26.1	-	260.0	62.9	0.08	95
24.25	72.0	415	-	260.0	19.0	-	260.0	53.4	0.0664	95
25.25	72.0	415	-	260.0	18.4	-	260.0	53.4	0.0664	95
26.75	72.0	415	-	260.0	17.8	-	260.0	52.2	0.0664	95
27.25	72.0	415	-	260.0	17.5	-	260.0	52.2	0.0664	95
10.75	73.0	415	-	260.0	17.2	-	260.0	52.2	0.0664	95
29.25	72.0	415	-	260.0	17.2	-	260.0	51.6	0.0664	95
30.25	72.0	415	-	260.0	17.2	-	260.0	51.6	0.0664	95
31.25	72.0	415	-	260.0	16.9	-	260.0	51.6	0.0664	95
32.25	72.0	415	-	260.0	17.2	-	260.0	51.6	0.0664	95

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: Dec 1,2,3/89

Mode: FBM
Operator: DJ

Run Number: 22

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HSC-04			HEM-07			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
33.8	74.0	420	-	265.0	16.0	-	265.0	49.9	-	95
36.8	73.0	420	-	265.0	16.0	-	265.0	49.3	-	95
39.8	-	415	-	257.5	15.4	-	257.5	49.3	-	95
42.8	-	415	-	252.5	15.4	-	252.5	49.3	-	95
45.8	-	410	-	250.0	14.8	-	250.0	48.7	-	95
48.8	72.0	410	-	250.0	13.7	-	250.0	46.3	-	95
51.8	73.0	410	-	250.0	14.2	-	250.0	46.3	-	95
54.8	73.0	410	-	250.0	13.7	-	250.0	46.9	-	95
57.8	73.0	410	-	250.0	14.8	-	250.0	46.9	-	95
60.8	-	410	-	250.0	14.2	-	250.0	46.3	-	95
63.8	-	410	-	250.0	13.1	-	250.0	46.3	-	95
66.8	-	410	-	250.0	12.5	-	250.0	44.5	-	95
69.8	-	410	-	250.0	11.9	-	250.0	42.1	-	95
72.8	74.0	410	-	250.0	10.7	-	250.0	40.4	-	95
75.8	74.0	405	-	247.5	9.5	-	247.5	33.8	-	95
78.8	73.0	410	-	250.0	8.9	-	250.0	32.0	-	95
81.8	73.0	410	-	250.0	9.5	-	250.0	32.0	-	95
84.8	73.0	410	-	250.0	9.5	-	250.0	32.0	-	95
87.8	72.0	410	-	250.0	8.9	-	250.0	29.7	-	95
90.8	73.0	410	-	250.0	8.3	-	250.0	27.3	-	95
93.8	73.0	410	-	250.0	8.3	-	250.0	26.1	-	95

* Inaccurate measurement, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: Dec 4,5,6/89

Mode: FBM
Operator: DJ

Run Number: 22

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HSC-04			HEM-07			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
96.1	72.0	415	-	260.0	7.7	-	260.0	24.9	0	95
96.3	71.0	415	-	260.0	7.7	-	260.0	25.5	0	95
97.3	73.0	415	-	260.0	8.0	-	260.0	26.7	0.0278	95
98.3	73.0	415	-	260.0	8.0	-	260.0	26.7	0.0278	95
99.3	73.0	415	-	260.0	8.0	-	260.0	26.7	0.0278	95
101.3	72.0	415	-	260.0	8.0	-	260.0	26.7	0.0278	95
102.3	72.0	415	-	260.0	8.0	-	260.0	26.7	0.0278	95
120.8	73.0	415	-	260.0	8.6	-	260.0	29.1	0.0278	95
121.3	73.0	415	-	260.0	8.6	-	260.0	32.0	0.0278	95
122.3	73.0	415	-	260.0	8.9	-	260.0	31.2	0.034	95
123.3	73.0	415	-	260.0	8.9	-	260.0	31.2	0.034	95
124.5	71.0	415	-	260.0	8.9	-	260.0	31.2	0.034	95
125.8	73.0	415	-	260.0	8.9	-	260.0	32.0	0.034	95
127.3	72.0	415	-	260.0	9.2	-	260.0	33.2	0.034	95
128.3	72.0	415	-	260.0	9.2	-	260.0	32.0	0.0462	95
135.3	72.0	415	-	260.0	8.9	-	260.0	32.6	0.0355	95
145.3	73.0	415	-	260.0	8.9	-	260.0	33.2	0.0355	95

Cleaned for 2 hours with 4XMC-3.

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* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: Dec 6,7,8/89

Mode: FBM
Operator: DJ

Run Number: 23

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HST-04 Flow Rate (L/min)*	HST-04 Average Pressure (kPa)	HST-04 Flux Rate (LMH)	HEM-07 Flow Rate (L/min)*	HEM-07 Average Pressure (kPa)	HEM-07 Flux Rate (LMH)	Conc. Bleed Rate (L/min)	Volume Reduction (%)
0.0	71.0	415	-	260.0	277.8	-	260.0	131.8	0	95
0.3	71.0	415	-	260.0	252.8	-	260.0	116.9	0	95
0.5	72.0	415	-	260.0	242.1	-	260.0	112.2	0	95
0.8	73.0	415	-	260.0	235.0	-	260.0	105.0	0.266	95
1.0	74.0	415	-	260.0	227.9	-	260.0	108.6	0.266	95
18.5	71.0	405	-	267.5	117.5	-	267.5	57.0	0.266	95
19.0	71.0	415	-	260.0	115.7	-	260.0	51.0	0.14	95
21.0	73.0	415	-	260.0	112.2	-	260.0	48.7	0.14	95
22.5	72.0	415	-	260.0	103.3	-	260.0	44.5	0.14	95
23.0	73.0	415	-	260.0	102.7	-	260.0	47.5	0.14	95
24.5	73.0	415	-	260.0	93.8	-	260.0	39.8	0.14	95
26.0	73.0	415	-	260.0	90.2	-	260.0	39.2	0.113	95
43.0	72.0	415	-	260.0	73.0	-	260.0	26.7	0.113	95
43.5	73.0	415	-	260.0	77.2	-	260.0	30.9	0.098	95
45.0	73.0	415	-	260.0	74.8	-	260.0	29.7	0.098	95
46.0	72.0	415	-	260.0	74.2	-	260.0	29.7	0.0938	95
47.5	73.0	415	-	260.0	74.2	-	260.0	29.7	0.0938	95
49.0	73.0	415	-	260.0	74.2	-	260.0	29.7	0.0938	95
50.0	73.0	415	-	260.0	74.8	-	260.0	29.7	0.0938	95

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: Dec 8-11/89

Mode: FBM
Operator: DJ

Run Number: 23

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HST-04			HEM-07			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
54.7	72.0	415	-	265.0	77.2	-	265.0	31.5	0.0938	95
58.0	73.0	415	-	265.0	76.0	-	265.0	30.9	0.0938	95
61.0	73.0	420	-	265.0	78.3	-	265.0	30.9	0.0938	95
63.5	73.0	415	-	260.0	76.0	-	260.0	29.1	0.0938	95
67.0	73.0	420	-	260.0	73.6	-	260.0	28.5	0.0938	95
70.0	74.0	420	-	267.5	71.2	-	267.5	27.9	0.0938	95
74.0	73.0	420	-	267.5	61.7	-	267.5	24.3	0.0938	95
79.0	72.0	420	-	265.0	59.9	-	265.0		0.0938	95
82.0	73.0	420	-	267.5	57.6	-	267.5		0.0938	95
85.0	72.0	420	-	267.5	54.0	-	267.5		0.0938	95
87.5	73.0	420	-	267.5	52.8	-	267.5		0.0938	95
91.0	73.0	420	-	267.5	52.2	-	267.5		0.0938	95
94.0	73.0	420	-	267.5	51.6	-	267.5		0.0938	95
97.0	73.0	420	-	267.5	45.7	-	267.5		0.0938	95
100.0	73.0	420	-	267.5	45.1	-	267.5		0.0938	95
102.5	73.0	420	-	267.5	42.1	-	267.5		0.0938	95
106.0	73.0	420	-	267.5	39.8	-	267.5		0.0938	95
109.7	73.0	420	-	267.5	39.2	-	267.5		0.0938	95
111.4	73.0	420	-	267.5	38.6	-	267.5		0.0938	95
114.4	72.0	415	-	260.0	35.6	-	260.0	12.8	0.0938	95

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 11-Dec-89

Mode: FBM
Operator: DJ

Run Number: 23

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HST-04			HEM-07			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
114.4	72.0	415	-	260.0	35.6	-	260.0	12.8	0.0938	95
115.0	73.0	415	-	260.0	36.2	-	260.0	12.8	0.0435	95
116.0	73.0	415	-	260.0	36.2	-	260.0	12.8	0.0435	95
117.0	73.0	415	-	260.0	36.2	-	260.0	12.8	0.0435	95
118.5	72.0	415	-	260.0	35.6	-	260.0	12.5	0.0435	95
120.5	73.0	415	-	260.0	35.6	-	260.0	11.9	0.0435	95
139.5	72.0	415	-	260.0	30.3	-	260.0	10.1	0.033	95
140.5	72.0	415	-	260.0	30.3	-	260.0	10.1	0.033	95
142.5	73.0	415	-	260.0	31.2	-	260.0	10.1	0.033	95
145.5	73.0	415	-	260.0	31.2	-	260.0	10.7	0.033	95
147.0	72.0	415	-	260.0	30.3	-	260.0	10.4	0.033	95
163.0	73.0	415	-	260.0	31.5	-	260.0	10.7	0.033	95

Cleaned for 2 hours with 4XMC-3.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 13-Dec-89

Mode: FBM
Operator: DJ

Run Number: 24

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HST-04			HEM-07			Conc. Bleed Rate (L/min)	Volume Reduction (%)	pH
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)			
0.0	71.0	415	-	260.0	249.3	-	260.0	169.1	0	95	9
0.3	72.0	415	-	260.0	218.4	-	260.0	131.8	0.3	95	9
0.5	71.0	415	-	260.0	192.9	-	260.0	108.0	0.3	95	9
1.0	73.0	415	-	260.0	178.1	-	260.0	95.0	0.3	95	9
1.5	73.0	415	-	260.0	167.4	-	260.0	86.1	0.195	95	9
2.0	73.0	415	-	260.0	166.2	-	260.0	80.1	0.195	95	9
3.0	73.0	415	-	260.0	154.3	-	260.0	74.2	0.195	95	9
3.5	73.0	415	-	260.0	145.4	-	260.0	70.0	0.195	95	9
8.0	73.0	415	-	260.0	129.4	-	260.0	59.4	0.175	95	9
18.0	73.0	415	-	260.0	92.0	-	260.0	47.5	0.175	95	9
18.5	73.0	415	-	260.0	92.0	-	260.0	47.5	0.125	95	9
20.0	73.0	415	-	260.0	93.8	-	260.0	50.4	0.125	95	9
21.5	73.0	415	-	260.0	99.7	-	260.0	53.4	0.125	95	9
23.0	73.0	415	-	260.0	92.6	-	260.0	46.3	0.125	95	9
24.5	73.0	415	-	260.0	87.2	-	260.0	48.1	0.125	95	9
25.5	73.0	415	-	260.0	86.7	-	260.0	47.5	0.125	95	9
26.5	73.0	415	-	260.0	86.7	-	260.0	47.5	0.125	95	9
42.0	73.0	415	-	260.0	65.3	-	260.0	38.6	0.094	95	9
43.5	74.0	415	-	260.0	65.3	-	260.0	43.3	0.094	95	10.5
44.5	73.0	415	-	260.0	60.5	-	260.0	44.5	0.094	95	10
46.0	73.0	415	-	260.0	62.9	-	260.0	47.5	0.094	95	10
48.0	73.0	415	-	260.0	60.5	-	260.0	47.5	0.094	95	10
50.0	73.0	415	-	260.0	55.8	-	260.0	45.7	0.094	95	10

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: Dec 15-18/89

Mode: FBM
Operator: DJ

Run
Number: 24

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HST-04			HEM-07			Conc. Bleed Rate (L/min)	Volume Reduction (%)	pH
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)			
54.5	73.0	415	-	262.5	55.8	-	262.5	48.1	0	95	10
58.0	73.0	420	-	265.0	57.0	-	265.0	49.9	0	95	10
60.5	72.0	415	-	262.5	59.4	-	262.5	47.5	0	95	10
63.0	73.0	420	-	265.0	53.4	-	265.0	46.3	0	95	10
66.0	73.0	415	-	262.5	52.2	-	262.5	46.3	0	95	10
68.5	73.0	415	-	262.5	51.6	-	262.5	45.7	0	95	10
71.5	73.0	415	-	262.5	53.4	-	262.5	52.2	0	95	10
74.5	72.0	420	-	267.5	50.4	-	267.5	48.7	0	95	10
78.5	74.0	415	-	265.0	43.9	-	265.0	48.7	0	95	10
81.5	74.0	415	-	265.0	55.8	-	265.0	59.4	0	95	10
85.5	74.0	415	-	265.0	48.7	-	265.0	49.9	0	95	10
89.5	73.0	415	-	265.0	53.4	-	265.0	52.2	0	95	10
92.5	73.0	415	-	265.0	53.4	-	265.0	51.0	0	95	10
95.5	73.0	420	-	267.5	53.4	-	267.5	52.2	0	95	10
98.5	73.0	420	-	267.5	52.2	-	267.5	51.6	0	95	10
102.5	74.0	420	-	267.5	52.8	-	267.5	52.2	0	95	10
105.0	73.0	420	-	267.5	55.8	-	267.5	52.8	0	95	10
108.5	73.0	420	-	267.5	56.4	-	267.5	53.4	0	95	10
113.5	72.0	425	-	267.5	55.8	-	267.5	53.4	0	95	10
116.5	67.0	425	-	267.5	52.2	-	267.5	51.0	0	95	10
117.3	62.0	425	-	272.5	54.6	-	272.5	48.7	0	95	10

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: Dec 18/89

Mode: FBM
Operator: DJ

Run
Number: 24

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HST-04			HEM-07			Conc. Bleed Rate (L/min)	Volume Reduction (%)	pH
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)			
117.3	62.0	425	-	272.5	54.6	-	272.5	48.7	0	95	10
118.0	66.0	415	-	260.0	46.3	-	260.0	42.7	0.094	95	10
119.0	71.0	415	-	260.0	45.1	-	260.0	45.1	0.094	95	10
119.5	73.0	415	-	260.0	45.7	-	260.0	49.3	0.094	95	11
120.5	74.0	415	-	260.0	47.5	-	260.0	54.6	0.094	95	11.5
122.0	74.0	415	-	260.0	44.5	-	260.0	53.4	0.094	95	11.5
137.0	73.0	415	-	260.0	32.0	-	260.0	40.4	0.0664	95	11
138.0	73.0	415	-	260.0	27.3	-	260.0	35.6	0.0664	95	11
139.3	72.0	415	-	260.0	27.3	-	260.0	35.6	0.0664	95	11
141.0	73.0	415	-	260.0	27.3	-	260.0	35.6	0.0664	95	11
142.5	73.0	415	-	260.0	24.9	-	260.0	34.4	0.0445	95	11
143.0	73.0	415	-	260.0	23.7	-	260.0	30.3	0.0445	95	11
162.5	73.0	415	-	260.0	16.6	-	260.0	22.0	0.0445	95	11

Cleaned for 2 hours with 4XMC-3. Preserved membranes in MP-1.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 9-Jan-90

Mode: FBM
Operator: BM

Run
Number: 25

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HEM-09			Conc. Bleed Rate (L/min)	Volume Reduction (%)	pH
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)			
0.0	70.0	415	-	-	-	-	260.0	527.0	0	0.0	9
0.3	73.0	415	-	-	-	-	260.0	491.4	0	18.6	9
0.5	74.0	415	-	-	-	-	260.0	491.4	0	30.9	9
0.8	73.0	415	-	-	-	-	260.0	484.3	0	40.0	9
1.0	72.0	415	-	260.0	116.3	-	260.0	477.2	0	47.6	9
1.3	73.0	415	-	260.0	103.9	-	260.0	470.1	0	53.9	9
1.5	73.0	415	-	260.0	95.0	-	260.0	451.1	0	58.7	9
16.3	73.0	415	-	260.0	42.7	-	260.0	284.9	0	92.8	9
17.0	73.0	415	-	260.0	44.5	-	260.0	292.0	0	93.1	9
18.0	73.0	415	-	260.0	43.9	-	260.0	292.0	0	93.3	9
19.0	73.0	415	-	260.0	43.9	-	260.0	284.9	0	93.6	9
21.0	73.0	415	-	260.0	43.3	-	260.0	267.1	0	94.0	9
22.0	73.0	415	-	260.0	40.4	-	260.0	249.3	0	94.2	9
23.0	73.0	415	-	260.0	40.4	-	260.0	249.3	0	94.4	9
24.5	73.0	415	-	260.0	39.8	-	260.0	249.3	0	95.1	9
40.3	73.0	415	-	260.0	14.8	-	260.0	98.5	0	95.0	9
41.0	73.0	415	-	260.0	14.2	-	260.0	96.1	0	95.0	9

Cleaned for 2 hours with 4XMC-3. Sponge balls were introduced to the system at the begining and the end of the cleaning (16 each time).

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 11-Jan-90

Mode: FBM
Operator: BM

Run Number: 26

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HEM-09			Conc. Bleed Rate (L/min)	Volume Reduction (%)	pH
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)			
41.0	73.0	420	-	-	100.9	-	262.5	320.5	0	95.0	9.0
41.3	73.0	415	-	-	54.6	-	260.0	356.1	0	95.0	9.0
41.8	73.0	415	-	-	54.6	-	260.0	238.6	0	95.0	9.0
42.0	73.0	415	-	-	51.0	-	207.5	0.0	0	94.0	9.0
43.0	73.0	415	-	260.0	48.7	-	207.5	0.0	0	93.5	9.0
59.5	73.0	415	-	257.5	25.5	-	207.5	0.0	0	92.3	9.0
62.5	73.0	415	-	257.5	24.9	-	207.5	0.0	0	92.1	9.0
65.5	73.0	415	-	257.5	24.3	-	207.5	0.0	0	91.9	9.0
68.5	73.0	415	-	257.5	23.7	-	207.5	0.0	0	91.7	9.0
71.5	73.0	415	-	260.0	22.6	-	207.5	0.0	0	91.3	9.0
74.5	73.0	415	-	260.0	22.0	-	207.5	0.0	0	91.1	9.0
77.5	73.0	415	-	260.0	19.0	-	207.5	0.0	0	89.9	9.0
80.5	73.0	415	-	260.0	19.0	-	207.5	0.0	0	89.9	9.0
83.5	73.0	415	-	260.0	17.8	-	207.5	0.0	0	89.3	9.0
86.5	73.0	415	-	260.0	16.6	-	207.5	0.0	0	88.6	9.0
92.5	73.0	420	-	262.5	16.0	-	210.0	0.0	0	88.2	9.0
95.5	73.0	420	-	210.0	15.4	-	210.0	0.0	0	87.8	9.0

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 11-Jan-90

Mode: FBM
Operator: BM

Run Number: 26

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-07			HEM-09			Conc. Bleed Rate (L/min)	Volume Reduction (%)	pH
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)			
98.5	73.0	415	-	260.0	14.2	-	0.0	0.0	0	87.0	9.0
101.5	73.0	415	-	260.0	13.7	-	0.0	0.0	0	86.5	9.0
104.5	73.0	415	-	260.0	12.5	-	0.0	0.0	0	85.4	9.0
113.5	73.0	415	-	260.0	11.9	-	0.0	0.0	0	84.7	9.0
119.5	73.0	415	-	260.0	10.7	-	0.0	0.0	0	83.3	9.0
122.5	73.0	415	-	260.0	10.1	-	0.0	0.0	0	82.5	9.0
125.5	73.0	415	-	260.0	10.1	-	0.0	0.0	0	82.5	9.0
128.5	73.0	415	-	260.0	9.5	-	0.0	0.0	0	81.6	9.0
131.0	73.0	415	-	260.0	8.6	-	0.0	0.0	0	87.9	9.0
132.0	73.0	415	-	267.5	9.5	-	0.0	0.0	0	88.9	9.0
133.0	73.0	415	-	262.5	9.5	-	0.0	0.0	0	88.9	9.0
134.0	73.0	415	-	260.0	10.7	-	0.0	0.0	0	90.0	9.0
135.0	73.0	415	-	260.0	10.7	-	0.0	0.0	0	90.0	9.0
136.0	73.0	415	-	260.0	11.3	-	0.0	0.0	0	90.5	9.0
137.0	73.0	415	-	260.0	11.3	-	0.0	0.0	0	90.5	9.0
138.0	73.0	415	-	260.0	11.0	-	0.0	0.0	0	90.2	9.0

Cleaned for 2 hours with 4XMC-3.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 16-Jan-90

Mode: MBM
Operator: JI,BM

Run
Number: 27

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-08 Flow Rate (L/min)*	HEM-08 Average Pressure (kPa)	HEM-08 Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Conc. Bleed Rate (L/min)	Volume Reduction (%)
0.0	73.0	415	-	260.0	379.8	-	-	0.0	0	0.0
0.3	73.0	415	-	260.0	356.1	-	-	0.0	0	14.1
0.5	73.0	415	-	260.0	349.0	-	-	0.0	0	24.4

Cleaned for 2 hours with 4XMC-3.

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* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 19-Jan-90

Mode: Stability
Operator: BM

Run
Number: **28**

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-08 Flow Rate (L/min)*	HEM-08 Average Pressure (kPa)	HEM-08 Flux Rate (LMH)	- Flow Rate (L/min)*	- Average Pressure (kPa)	- Flux Rate (LMH)	Conc. Bleed Rate (L/min)	Volume Reduction (%)
0.0	73.0	415	-	260.0	341.9	-	-	-	0	0.0
0.5	73.0	415	-	260.0	295.6	-	-	-	0	0.0
2.0	73.0	415	-	260.0	281.3	-	-	-	0	0.0
3.3	73.0	415	-	260.0	270.0	-	-	-	0	0.0
5.3	73.0	415	-	260.0	262.9	-	-	-	0	0.0
20.3	73.0	415	-	260.0	47.5	-	-	-	0	0.0
23.3	73.0	410	-	257.5	47.5	-	-	-	0	0.0
24.3	73.0	415	-	260.0	47.5	-	-	-	0	0.0
29.3	73.0	415	-	260.0	44.5	-	-	-	0	0.0
31.3	73.0	410	-	257.5	23.7	-	-	-	0	0.0
35.3	73.0	405	-	255.0	23.7	-	-	-	0	0.0
38.3	73.0	405	-	255.0	23.7	-	-	-	0	0.0
41.3	73.0	405	-	255.0	23.7	-	-	-	0	0.0
43.3	73.0	410	-	257.5	20.8	-	-	-	0	0.0
47.3	73.0	410	-	257.5	20.8	-	-	-	0	0.0
54.3	73.0	410	-	257.5	20.8	-	-	-	0	0.0
55.3	73.0	410	-	205.0	17.8	-	-	-	0	0.0

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 19-Jan-90

Mode: Stability
Operator: BM

Run
Number: 28

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-08			-			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
59.3	73.0	410	-	257.5	17.8	-	-	-	0	0.0
62.3	73.0	410	-	257.5	17.8	-	-	-	0	0.0
65.3	73.0	410	-	257.5	17.8	-	-	-	0	0.0
68.8	73.0	415	-	262.5	18.4	-	-	-	0	0.0
69.8	73.0	415	-	262.5	18.4	-	-	-	0	0.0
70.8	73.0	415	-	257.5	18.4	-	-	-	0	0.0
71.8	73.0	415	-	260.0	18.4	-	-	-	0	0.0
72.8	73.0	415	-	260.0	18.4	-	-	-	0	0.0
73.8	73.0	415	-	260.0	18.4	-	-	-	0	0.0
74.8	73.0	415	-	257.5	18.4	-	-	-	0	0.0
91.8	73.0	415	-	260.0	18.4	-	-	-	0	0.0
92.8	73.0	415	-	257.5	18.4	-	-	-	0	0.0
93.8	73.0	415	-	257.5	18.4	-	-	-	0	0.0
94.8	73.0	415	-	260.0	18.4	-	-	-	0	0.0
95.8	73.0	415	-	260.0	18.4	-	-	-	0	0.0
96.8	73.0	415	-	260.0	18.4	-	-	-	0	0.0

Cleaned for 2 hours with 4XMC-3.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 23-Jan-90

Mode: FBM
Operator: BM

Run
Number: 29

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-08 Flow Rate (L/min)*	HEM-08 Average Pressure (kPa)	HEM-08 Flux Rate (LMH)	HST-05 Flow Rate (L/min)*	HST-05 Average Pressure (kPa)	HST-05 Flux Rate (LMH)	Conc. Bleed Rate (L/min)	Volume Reduction (%)
0.0	73.0	415	-	260.0	68.8	-	260.0	500.9	0	0.0
0.5	73.0	415	-	260.0	34.4	-	260.0	295.6	0	28.7
1.0	73.0	415	-	260.0	23.7	-	260.0	238.6	0	40.0
1.5	73.0	415	-	260.0	21.4	-	260.0	231.5	0	47.3
17.5	73.0	415	-	260.0	7.7	-	260.0	77.2	0	85.1
19.0	73.0	415	-	260.0	8.1	-	260.0	79.5	0	85.6
20.0	73.0	415	-	260.0	7.7	-	260.0	77.2	0	86.0
21.0	73.0	415	-	260.0	7.4	-	260.0	76.0	0	86.2
22.0	73.0	415	-	260.0	7.2	-	260.0	73.6	0	86.5
23.0	73.0	415	-	260.0	7.1	-	260.0	73.6	0	86.8
24.0	73.0	415	-	260.0	6.5	-	260.0	67.1	0	87.0
25.0	73.0	415	-	260.0	6.2	-	260.0	65.3	0	87.2
42.0	73.0	415	-	260.0	3.6	-	260.0	41.5	0	89.6

Cleaned for 7 hours with 4XMC-3.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 26-Jan-90

Mode: FBM
Operator: BM

Run
Number: 30

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-08			HST-05			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
0.0	73.0	415	-	-	200.6	-	260.0	207.7	0	0.0
0.3	73.0	415	-	-	59.9	-	260.0	80.7	0	10.9
0.7	73.0	415	-	-	40.4	-	260.0	67.7	0	17.8
0.8	73.0	415	-	-	37.4	-	260.0	61.7	0	18.8
1.0	73.0	415	-	260.0	33.8	-	260.0	59.9	0	21.5
1.5	73.0	415	-	260.0	29.1	-	260.0	56.4	0	26.2
2.5	73.0	415	-	260.0	25.2	-	260.0	53.4	0	33.4
3.0	73.0	415	-	260.0	22.3	-	260.0	47.5	0	36.2
4.0	73.0	415	-	260.0	22.3	-	260.0	48.1	0	40.9
4.5	73.0	415	-	260.0	22.0	-	260.0	47.5	0	43.0
7.5	73.0	415	-	260.0	19.0	-	260.0	41.5	0	52.5
22.5	73.0	415	-	260.0	14.2	-	260.0	27.3	0	71.2
25.5	73.0	415	-	260.0	13.1	-	260.0	24.9	0	72.9
28.5	73.0	415	-	260.0	9.5	-	260.0	20.2	0	74.2
46.5	73.0	415	-	260.0	4.7	-	260.0	13.7	0	78.5
52.5	73.0	415	-	260.0	3.0	-	260.0	11.9	0	79.3
55.5	73.0	415	-	260.0	3.0	-	260.0	11.9	0	79.6
70.5	73.0	415	-	260.0	3.2	-	260.0	8.0	0	81.0
71.5	73.0	415	-	260.0	3.0	-	260.0	8.3	0	81.0

Cleaned for 2 hours with 4XMC-3 followed by 0.5 hours cleaning with MC-1 at pH 2.0.

* Inaccurate measurement, see report Section 2.3.2

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 29-Jan-90

Mode: FBM
Operator: BM

Run
Number: 31

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-08			HST-05			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
0.0	73.0	415	-	260.0	132.9	-	260.0	178.1	0	81.0
0.5	73.0	415	-	260.0	95.0	-	260.0	160.2	0	81.9
1.0	73.0	415	-	260.0	85.5	-	260.0	122.3	0	82.5
18.0	73.0	415	-	260.0	24.9	-	260.0	67.7	0	90.3
19.0	73.0	415	-	260.0	24.3	-	260.0	67.1	0	90.4
20.0	73.0	415	-	260.0	23.1	-	260.0	66.5	0	90.6
21.0	73.0	415	-	260.0	22.6	-	260.0	65.3	0	90.7
22.0	73.0	415	-	260.0	22.6	-	260.0	64.7	0	90.9
23.0	73.0	415	-	260.0	22.6	-	260.0	64.7	0	91.0
24.0	73.0	415	-	260.0	22.3	-	260.0	62.3	0	91.1
25.0	73.0	415	-	260.0	22.0	-	260.0	59.4	0	91.2
42.0	73.0	415	-	260.0	10.7	-	260.0	41.5	0	92.6

Cleaned for 4 hours with 4XMC-3.

* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 31-Jan-90

Mode: FBM
Operator: BM

Run
Number: 32

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-08			HST-05			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
0.0	73.0	415	-	260.0	123.4	-	260.0	225.5	0	81.0
0.5	73.0	415	-	260.0	78.3	-	260.0	168.6	0	92.7
1.0	73.0	415	-	260.0	71.2	-	260.0	154.3	0	92.8
1.5	73.0	415	-	260.0	65.3	-	260.0	148.4	0	92.9
2.5	73.0	415	-	260.0	59.9	-	260.0	142.4	0	93.1
18.5	73.0	415	-	260.0	29.7	-	260.0	90.2	0	94.8
19.5	73.0	415	-	260.0	29.7	-	260.0	106.8	0.11	95
21.5	73.0	415	-	260.0	27.9	-	260.0	99.1	0.11	95
22.5	73.0	415	-	260.0	27.3	-	260.0	98.5	0.11	95
23.5	73.0	415	-	260.0	26.7	-	260.0	95.0	0.11	95
24.5	73.0	415	-	260.0	26.1	-	260.0	92.6	0.11	95
25.5	73.0	415	-	260.0	23.7	-	260.0	89.0	0.091	95
41.0	73.0	415	-	260.0	14.2	-	260.0	71.2	0.091	94

Cleaned for 2 hours with 4XMC-3.

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* Inaccurate measurement, see report Section 2.3.2

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 2-Feb-90

Mode: FBM
Operator: BM

Run
Number: 33

Elapsed Time (h)	Feed Temp. (°C)	Inlet Pressure (kPa)	HEM-08			HST-05			Conc. Bleed Rate (L/min)	Volume Reduction (%)
			Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)	Flow Rate (L/min)*	Average Pressure (kPa)	Flux Rate (LMH)		
0.0	73.0	415	-	-	95.0	-	260.0	213.7	0.128	97.6
0.5	73.0	415	-	-	87.8	-	260.0	178.1	0.128	97.2
1.0	73.0	415	-	-	57.0	-	260.0	170.9	0.128	97.2
1.3	73.0	415	-	-	55.8	-	260.0	166.2	0.128	97.1
2.3	73.0	415	-	260.0	42.1	-	260.0	138.9	0.091	97.1
3.3	73.0	415	-	260.0	40.4	-	260.0	137.7	0.091	97.1
5.3	73.0	415	-	260.0	41.5	-	260.0	122.3	0.091	96.8
10.3	73.0	415	-	260.0	27.3	-	260.0	118.7	0.091	96.4
13.8	73.0	415	-	260.0	23.7	-	260.0	121.1	0.091	96.4
16.8	73.0	415	-	260.0	22.6	-	260.0	127.0	0.091	96.5
19.8	73.0	415	-	260.0	22.6	-	260.0	137.1	0.091	96.7
21.8	73.0	415	-	260.0	21.4	-	260.0	136.5	0.091	96.7
23.8	73.0	415	-	260.0	21.4	-	260.0	135.3	0.091	96.7
25.8	73.0	415	-	260.0	19.0	-	260.0	129.4	0.091	96.5
27.5	73.0	415	-	260.0	17.2	-	260.0	123.4	0.091	96.3
28.8	73.0	415	-	260.0	16.0	-	260.0	112.2	0.091	96.0
31.8	73.0	415	-	260.0	16.6	-	260.0	123.4	0.091	96.3
34.8	73.0	415	-	260.0	14.8	-	260.0	99.7	0.091	95.5
37.8	73.0	415	-	260.0	14.8	-	260.0	103.3	0.091	95.6
40.75	73.0	415	-	260.0	14.2	-	260.0	102.1	0.091	95.6
42.75	73.0	415	-	260.0	13.7	-	260.0	99.7	0.091	95.5
46.75	73.0	415	-	260.0	10.7	-	260.0	98.5	0.091	95.3
49.75	73.0	415	-	260.0	9.5	-	260.0	37.2	0.091	94.7
52.75	73.0	415	-	260.0	8.3	-	260.0	83.1	0.091	94.4
55.75	73.0	415	-	260.0	6.5	-	260.0	80.1	0.091	94.1
70.25	73.0	415	-	260.0	4.7	-	260.0	71.2	0.091	93.4

Cleaned for 2 hours with 4XMC-3.

* Inaccurate measurement, see report Section 2.3.2

APPENDIX D

Site "B" - Analytical Data

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 18-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 2

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	340.5	3936.9	-	79.0	0.2	99.7	50.2	36.5
TDO (mg/L) "am"	-	-	-	4.0	0.2	95.0	50.2	-1155.0
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	15312.0	353.3	-	224.0	0.5	99.8	89.6	60.0
TSS (mg/L)	1906.7	872.0	-	394.2	9.7	97.5	180.3	54.3
TDS (mg/L)	20416.0	26928.0	-	27664.0	27364.0	1.1	26948.0	2.6
TSM (mg/L)"am"	17218.7	1225.3	-	618.2	10.2	98.4	269.9	56.3
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	600.0	605.0	-0.8	610.0	-1.7
Mg (mg/L)	-	-	-	218.0	220.0	-0.9	223.0	-2.3
Si (mg/L)	-	-	-	36.8	36.4	1.1	36.0	2.2
Na (mg/L)	-	-	-	8080.0	8190.0	-1.4	8290.0	-2.6
Cl (mg/L)	-	-	-	15100.0	15600.0	-3.3	15700.0	-4.0
HCO3 (mg/L)	-	-	-	123.1	112.3	8.8	107.6	12.6
SO4 (mg/L)	-	-	-	59.0	60.0	-1.7	55.0	6.8
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	7.3	7.2	-	7.3	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 19-Jan-89

Mode: MBM
Operator: PCF

Run Number: 3

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	5216.5	97.9	-	17.1	38.6	-125.7	2.6	84.8
TDO (mg/L) "am"	-	-	-	4.0	38.6	-865.0	2.6	35.0
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	243.7	148.5	-	32.3	24.7	23.5	0.4	98.8
TSS (mg/L)	432.7	360.6	-	199.5	161.0	19.3	32.0	84.0
TDS (mg/L)	42668.0	44136.0	-	42924.0	429.4	99.0	43372.0	-1.0
TSM (mg/L)"am"	676.4	509.1	-	231.8	185.7	19.9	32.4	86.0
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	980.0	1000.0	-2.0	990.0	-1.0
Mg (mg/L)	-	-	-	390.0	390.0	0.0	390.0	0.0
Si (mg/L)	-	-	-	26.1	26.3	-0.8	26.3	-0.8
Na (mg/L)	-	-	-	12600.0	13600.0	-7.9	13000.0	-3.2
Cl (mg/L)	-	-	-	23700.0	23300.0	1.7	23600.0	0.4
HCO3 (mg/L)	-	-	-	<0.5	99.6	-	107.5	-
SO4 (mg/L)	-	-	-	86.0	105.0	-22.1	104.0	-20.9
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	92.5	7.6	-	7.2	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B" Mode: MBM Run
Date: 20-Jan-89 Operator: PCF Number: 4A

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	2308.5	114.1	-	67.1	8.2	87.8	24.6	63.3
TDO (mg/L) "am"	-	-	-	3.9	8.2	-110.3	24.6	-530.8
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	228.5	48.6	-	27.7	1.9	93.1	11.4	58.8
TSS (mg/L)	651.9	201.2	-	152.3	48.2	68.4	87.2	42.7
TDS (mg/L)	50948.0	38120.0	-	37024.0	130508.0	-252.5	36236.0	2.1
TSM (mg/L)"am"	880.4	249.8	-	180.0	50.1	72.2	98.6	45.2
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-

ZENON ENVIRONMENTAL INC.

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 21-Jan-89
Mode: MBM
Operator: PCF
Run Number: 4B

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	-	-	421.5	408.1	6.5	98.4	175.0	57.1
TDO (mg/L) "am"	-	-	-	9.3	6.5	30.1	175.0	-1781.7
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	301.1	68.0	9.5	86.0	85.0	-25.0
TSS (mg/L)	-	-	415.7	860.0	36.0	95.8	145.3	83.1
TDS (mg/L)	-	-	37848.0	37788.0	37440.0	0.9	38360.0	-1.5
TSM (mg/L)"am"	-	-	716.8	928.0	45.5	95.1	230.3	75.2
TSM (mg/L)"pm"								
IONS								
Ca (mg/L)	-	-	-	980.0	934.0	4.7	990.0	-1.0
Mg (mg/L)	-	-	-	390.0	375.0	3.8	390.0	0.0
Si (mg/L)	-	-	-	27.2	28.0	-2.9	27.4	-0.7
Na (mg/L)	-	-	-	12500.0	12200.0	2.4	12100.0	3.2
Cl (mg/L)	-	-	-	22000.0	23500.0	-6.8	21800.0	0.9
HCO3 (mg/L)	-	-	-	123.1	130.4	-5.9	126.8	-3.0
SO4 (mg/L)	-	-	-	85.0	106.0	-24.7	85.0	0.0
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH				7.5	7.5	-	7.5	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 23-Jan-89
Mode: MBM
Operator: PCF
Run Number: 5A

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	2761.1	206.6		44.1	4.3	90.2	40.1	9.1
TDO (mg/L) "am"	-	-	-	12.2	4.3	64.8	40.1	-228.7
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	310.3	93.1	-	21.9	1.4	93.6	12.5	42.9
TSS (mg/L)	477.2	225.7	-	190.4	9.2	95.2	47.5	75.1
TDS (mg/L)	52284.0	54286.0	-	55236.0	52956.0	4.1	54040.0	2.2
TSM(mg/L)"am"	787.5	318.8	-	212.3	10.6	95.0	60.0	71.7
TSM (mg/L)"pm"								
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 23-Jan-89

Mode: MBM
Operator: PCF

Run Number: **5B**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	-	-	464.7	485.4	70.2	85.5	235.2	51.5
TDO (mg/L) "am"	-	-		11.9	70.2	-489.9	235.2	-1876.5
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	570.5	432.6	70.1	83.8	171.3	60.4
TSS (mg/L)	-	-	281.5	334.8	24.1	92.8	100.9	69.9
TDS (mg/L)	-	-	43780.0	47640.0	52032.0	-9.2	50672.0	-6.4
TSM (mg/L)"am"	-	-	852.0	767.4	94.2	87.7	272.2	64.5
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	1260.0	1280.0	-1.6	1290.0	-2.4
Mg (mg/L)	-	-	-	516.0	521.0	-1.0	526.0	-1.9
Si (mg/L)	-	-	-	22.7	20.0	11.9	21.8	4.0
Na (mg/L)	-	-	-	16900.0	16900.0	0.0	17200.0	-1.8
Cl (mg/L)	-	-	-	30900.0	30400.0	1.6	31400.0	-1.6
HCO3 (mg/L)	-	-	-	94.2	100.1	-6.3	100.4	-6.6
SO4 (mg/L)	-	-	-	165.0	155.0	6.1	162.0	1.8
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	7.3	7.5	-	7.4	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 24-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 5C

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	49.1	95.4	-	528.6	0.4	99.9	7.2	98.6
TDO (mg/L) "am"	-	-	-	25.4	0.2	99.2	7.2	71.7
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	1461.8	126.1	-	425.6	1.1	99.7	131.9	69.0
TSS (mg/L)	502.1	369.7	-	203.7	1.1	99.5	63.1	69.0
TDS (mg/L)	53436.0	41376.0	-	45552.0	52656.0	-15.6	51344.0	-12.7
TSM (mg/L)"am"	1963.9	495.8	-	629.3	2.2	99.7	195.0	69.0
TSM (mg/L)"pm"								
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 24-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 5D

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	-	-	361.9	302.2	3.1	99.0	79.8	73.6
TDO (mg/L) "am"	-	-		7.0	3.1	55.7	79.8	-1040.0
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	233.0	293.3	2.0	99.3	56.2	80.8
TSS (mg/L)	-	-	148.1	190.0	3.8	98.0	38.8	79.6
TDS (mg/L)	-	-	40732.0	39288.0	41280.0	-5.1	42312.0	-7.7
TSM (mg/L)"am"	-	-	381.1	483.3	5.8	98.8	95.0	80.3
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	1010.0	924.0	8.5	924.0	8.5
Mg (mg/L)	-	-	-	406.0	390.0	3.9	392.0	3.4
Si (mg/L)	-	-	-	23.7	23.5	0.8	23.5	0.8
Na (mg/L)	-	-	-	12800.0	12400.0	3.1	12700.0	0.8
Cl (mg/L)	-	-	-	24700.0	24100.0	2.4	24600.0	0.4
HCO3 (mg/L)	-	-	-	109.7	114.2	-4.1	111.4	-1.5
SO4 (mg/L)	-	-	-	106.0	87.0	17.9	94.0	11.3
PHYSICAL	-	-	-	-	-	-	-	-
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	7.6	7.4	-	7.5	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 25-Jan-89

Mode: MBM
Operator: PCF

Run Number: 5E

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	110.2	20.3	-	84.1	4.9	94.2	7.3	91.3
TDO (mg/L) "am"	-	-	-	11.8	4.9	58.5	7.3	38.1
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	82.6	43.3	-	292.4	0.7	99.8	43.6	85.1
TSS (mg/L)	39.7	85.3	-	178.6	2.5	98.6	36.2	79.7
TDS (mg/L)	33700.0	33272.0	-	38992.0	41920.0	-7.5	40280.0	-3.3
TSM (mg/L)"am"	122.3	128.6	-	471.0	3.2	99.3	79.8	83.1
TSM (mg/L)"pm"								
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 25-Jan-89

Mode: MBM
Operator: PCF

Run Number: 5F

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	-	-	406.0	134.9	3.1	97.7	49.9	63.0
TDO (mg/L) "am"	-	-	-	8.8	3.1	64.8	49.9	-467.0
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	266.0	286.6	46.6	83.7	1.9	99.3
TSS (mg/L)	-	-	233.6	246.7	43.2	82.5	3.5	98.6
TDS (mg/L)	-	-	28328.0	28356.0	30360.0	-7.1	30352.0	-7.0
TSM (mg/L)"am"	-	-	499.6	533.3	89.8	83.2	5.4	99.0
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	632.0	627.0	0.8	577.0	8.7
Mg (mg/L)	-	-	-	262.0	261.0	0.4	240.0	8.4
Si (mg/L)	-	-	-	32.1	32.1	0.0	28.5	11.2
Na (mg/L)	-	-	-	9260.0	9410.0	-1.6	8160.0	11.9
Cl (mg/L)	-	-	-	18000.0	18000.0	0.0	15700.0	12.8
HCO3 (mg/L)	-	-	-	108.1	111.3	-3.0	100.2	7.3
SO4 (mg/L)	-	-	-	62.0	57.0	8.1	52.0	16.1
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	7.6	7.6	-	7.5	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 26-Jan-89

Mode: MBM
Operator: PCF

Run Number: 5G

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	959.4	48.5	-	330.0	1.6	99.5	34.3	89.6
TDO (mg/L) "am"	-	-	-	11.3	1.6	85.8	34.3	-203.5
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	26.1	85.8	-	295.0	3.4	98.8	35.3	88.0
TSS (mg/L)	83.1	162.5	-	225.5	0.9	99.6	44.5	80.3
TDS (mg/L)	21560.0	20980.0	-	29992.0	29765.0	0.8	29832.0	0.5
TSM (mg/L)"am"	109.2	248.3	-	520.5	4.3	99.2	79.8	84.7
TSM (mg/L)"pm"								
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"	Mode: MBM	Run	
Date: 26-Jan-89	Operator: PCF	Number:	5H

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	-	-	335.2	463.3	3.9	98.8	61.4	81.7
TDO (mg/L) "am"	-	-	-	6.7	-	-	-	-
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	464.9	373.0	3.5	99.1	64.2	82.8
TSS (mg/L)	-	-	424.4	356.6	1.0	99.7	88.1	75.3
TDS (mg/L)	-	-	24160.0	23400.0	21980.0	6.1	23276.0	0.5
TSM (mg/L)"am"	-	-	889.3	729.6	4.5	99.4	152.3	79.1
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	516.0	504.0	2.3	513.0	0.6
Mg (mg/L)	-	-	-	200.0	196.0	2.0	199.0	0.5
Si (mg/L)	-	-	-	33.6	35.0	-4.2	34.4	-2.4
Na (mg/L)	-	-	-	7160.0	7010.0	2.1	7450.0	-4.1
Cl (mg/L)	-	-	-	13200.0	13400.0	-1.5	13800.0	-4.5
HCO3 (mg/L)	-	-	-	125.6	126.8	-1.0	128.0	-1.9
SO4 (mg/L)	-	-	-	42.0	47.0	-11.9	47.0	-11.9
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	7.7	7.6	-	7.7	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 27-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 5I

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	125.9	75.8	-	394.9	7.0	98.2	30.3	92.3
TDO (mg/L) "am"	-	-	-	7.7	7.0	9.1	30.3	-293.5
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	19.4	46.4	-	304.0	2.9	99.0	45.2	85.1
TSS (mg/L)	88.6	168.5	-	307.2	9.6	96.9	63.1	79.5
TDS (mg/L)	36464.0	40744.0	-	22164.0	22736.0	-2.6	23212.0	-4.7
TSM (mg/L)"am"	108	214.9	-	611.2	12.5	98.0	108.3	82.3
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 27-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 5J

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-03	% Rej. HSC-03
OIL								
TO (mg/L) "am"	-	-	106.3	149.2	5.3	96.4	8.6	94.2
TDO (mg/L) "am"	-	-	-	15.6	-	-	-	-
TO (mg/L) "pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	173.9	169.5	0.5	99.7	61.0	64.0
TSS (mg/L)	-	-	249.1	266.1	3.3	98.8	119.0	55.3
TDS (mg/L)	-	-	30528.0	30876.0	30344.0	1.7	31232.0	-1.2
TSM (mg/L)"am"	-	-	420.0	435.6	3.8	99.1	180.0	58.7
TSM (mg/L)"pm"								
IONS								
Ca (mg/L)	-	-	-	667.0	671.0	-0.6	665.0	0.3
Mg (mg/L)	-	-	-	281.0	284.0	-1.1	281.0	0.0
Si (mg/L)	-	-	-	30.0	30.2	-0.7	29.5	1.7
Na (mg/L)	-	-	-	10200.0	9450.0	7.4	9310.0	8.7
Cl (mg/L)	-	-	-	18100.0	18100.0	0.0	18100.0	0.0
HCO3 (mg/L)	-	-	-	114.7	121.9	-6.3	119.9	-4.5
SO4 (mg/L)	-	-	-	59.0	65.0	-10.2	63.0	-6.8
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	7.7	7.6	-	7.6	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 30-Jan-89

Mode: MBM
Operator: PCF

Run
Number: **6A**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	51.1	129.0	-	76.5	4.1	94.6
TDO (mg/L) "am"	-	-	-	68.7	4.1	94.0
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	269.6	90.1	-	74.2	0.4	99.5
TSS (mg/L)	242.5	165.1	-	198.0	7.2	96.4
TDS (mg/L)	31460.0	38868.0	-	35900.0	34724.0	3.3
TSM (mg/L)"am"	512.1	255.2	-	272.2	7.6	97.2
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 30-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 6B

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	-	-	79.8	52.0	3.9	92.5
TDO (mg/L) "am"	-	-	-	7.8	-	-
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	80.7	60.6	-	-
TSS (mg/L)	-	-	699.3	612.4	-	-
TDS (mg/L)	-	-	34740.0	33700.0	35392.0	-5.0
TSM (mg/L)"am"	-	-	780.0	673.0	32.0	95.2
TSM (mg/L)"pm"						
IONS						
Ca (mg/L)	-	-	-	736.0	736.0	0.0
Mg (mg/L)	-	-	-	314.0	313.0	0.3
Si (mg/L)	-	-	-	29.6	26.8	9.5
Na (mg/L)	-	-	-	10200.0	11200.0	-9.8
Cl (mg/L)	-	-	-	19800.0	19500.0	1.5
HCO3 (mg/L)	-	-	-	114.1	108.0	5.3
SO4 (mg/L)	-	-	-	72.0	62.0	13.9
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	7.5	7.5	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 31-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 6C

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	739.2	108.5	-	74.8	1.7	97.7
TDO (mg/L) "am"	-	-	-	4.1	1.7	58.5
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	191.4	111.0	-	132.3	0.6	99.5
TSS (mg/L)	358.6	152.8	-	590.9	35.0	94.1
TDS (mg/L)	30892.0	26920.0	-	33120.0	34220.0	-3.3
TSM (mg/L)"am"	555.0	263.8	-	723.3	35.6	95.1
TSM (mg/L)"pm"						
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 31-Jan-89

Mode: MBM
Operator: PCF

Run
Number: 6D

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	-	-	56.7	30.6	4.1	86.6
TDO (mg/L) "am"	-	-	-	10.0	4.1	59.0
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	195.7	158.6	0.6	99.6
TSS (mg/L)	-	-	552.8	570.7	10.6	98.1
TDS (mg/L)	-	-	25628.0	26144.0	26940.0	-3.0
TSM (mg/L)"am"	-	-	748.5	729.3	11.2	98.5
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	548.0	537.0	2.0
Mg (mg/L)	-	-	-	227.0	226.0	0.4
Si (mg/L)	-	-	-	32.1	30.6	4.7
Na (mg/L)	-	-	-	7840.0	8790.0	-12.1
Cl (mg/L)	-	-	-	14600.0	14500.0	0.7
HCO3 (mg/L)	-	-	-	140.2	125.6	10.4
SO4 (mg/L)	-	-	-	47.0	44.0	6.4
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	7.7	7.5	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 1-Feb-89

Mode: MBM
Operator: PCF

Run
Number: 7A

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	60.5	7.2	-	21.7	3.8	82.5
TDO (mg/L) "am"	-	-	-	2.5	3.8	-52.0
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	710.4	9.6	-	15.3	-	-
TSS (mg/L)	1928.6	40.3	-	45.8	-	-
TDS (mg/L)	26464.0	24096.0	-	38684.0	23916.0	38.2
TSM (mg/L)"am"	2639.0	49.9	-	61.1	161.8*	-164.8*
TSM (mg/L)"pm"						
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

*Sample appeared soapy

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 1-Feb-89

Mode: MBM
Operator: PCF

Run Number: 7B

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	-	-	197.0	193.6	2.8	98.6
TDO (mg/L) "am"	-	-	-	-	-	-
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	204.2	215.2	0.2	99.9
TSS (mg/L)	-	-	337.9	358.9	28.4	92.1
TDS (mg/L)	-	-	32184.0	32588.0	33868.0	-3.9
TSM (mg/L)"am"	-	-	542.1	574.1	28.6	95.0
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	737.0	733.0	0.5
Mg (mg/L)	-	-	-	315.0	314.0	0.3
Si (mg/L)	-	-	-	25.7	24.6	4.3
Na (mg/L)	-	-	-	10600.0	10300.0	2.8
Cl (mg/L)	-	-	-	19000.0	19200.0	-1.1
HCO3 (mg/L)	-	-	-	128.0	124.3	2.9
SO4 (mg/L)	-	-	-	61.0	58.0	4.9
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	7.5	7.4	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 2-Feb-89

Mode: MBM
Operator: PCF

Run Number: 7C

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	376.0	121.0	-	45.7	5.3	88.4
TDO (mg/L) "am"	-	-	-	5.5	5.3	3.6
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	115.9	198.6	-	205.4	1.3	99.4
TSS (mg/L)	1813.1	647.6	-	371.7	38.1	89.7
TDS (mg/L)	39144.0	37228.0	-	33388.0	34120.0	-2.2
TSM (mg/L)"am"	1929.0	849.2	-	577.1	39.4	93.2
TSM (mg/L)"pm"						
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 2-Feb-89

Mode: MBM
Operator: PCF

Run Number: 7D

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	-	-	124.0	136.8	2.9	97.9
TDO (mg/L) "am"	-	-	-	17.7	2.9	83.6
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	305.8	203.9	1.6	99.2
TSS (mg/L)	-	-	612.1	376.1	29.5	92.2
TDS (mg/L)	-	-	35016.0	35876.0	36912.0	-2.9
TSM (mg/L)"am"	-	-	917.9	580.0	31.1	94.6
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	783.0	779.0	0.5
Mg (mg/L)	-	-	-	333.0	334.0	-0.3
Si (mg/L)	-	-	-	23.2	25.7	-10.8
Na (mg/L)	-	-	-	12000.0	10970.0	8.6
Cl (mg/L)	-	-	-	20100.0	20000.0	0.5
HCO3 (mg/L)	-	-	-	123.1	110.1	10.6
SO4 (mg/L)	-	-	-	57.0	52.0	8.8
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	7.3	7.5	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 6-Feb-89

Mode: MBM
Operator: PCF

Run
Number: **8A**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	40.3	68.9	-	13.9	3.7	73.4
TDO (mg/L) "am"	-	-	-	24.6	3.7	85.0
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	9.8	51.5	-	6.5	23.2	-256.9
TSS (mg/L)	38.4	50.0	-	23.3	344.8	-1379.8
TDS (mg/L)	40528.0	48496.0	-	43452.0	39312.0	9.5
TSM (mg/L)"am"	48.2	101.5	-	29.8	368.0	-1134.9
TSM (mg/L)"pm"						
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"	Mode: MBM	Run
Date: 6-Feb-89	Operator: PCF	Number: **8B**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	-	-	-	104.4	7.6	92.7
TDO (mg/L) "am"	-	-	-	9.9	7.6	23.2
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	-	88.6	-	-
TSS (mg/L)	-	-	-	267.5	-	-
TDS (mg/L)	-	-	-	41248.0	42536.0	-3.1
TSM (mg/L)"am"	-	-	-	356.1	7.2	98.0
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 7-Feb-89

Mode: MBM
Operator: PCF

Run
Number: 9A

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	119.5	32.0	-	40.7	3.4	91.6
TDO (mg/L) "am"	-	-	-	10.8	3.4	68.5
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	332.3	20.2	-	12.9	1.5	88.4
TSS (mg/L)	340.0	62.8	-	47.6	4.6	90.3
TDS (mg/L)	48720.0	48952.0	-	48864.0	49740.0	-1.8
TSM (mg/L)"am"	672.3	83.0	-	60.5	6.1	89.9
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 7-Feb-89

Mode: MBM
Operator: PCF

Run Number: **9B**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	-	-	-	134.5	11.9	91.2
TDO (mg/L) "am"	-	-	-	15.0	11.9	20.7
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	-	76.1	0.9	98.8
TSS (mg/L)	-	-	-	194.8	8.8	95.5
TDS (mg/L)	-	-	-	49180.0	49944.0	-1.6
TSM (mg/L)"am"	-	-	-	270.9	7.9	97.1
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 8-Feb-89

Mode: MBM
Operator: PCF

Run
Number: **10A**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	110.3	49.9	-	20.4	9.6	52.9
TDO (mg/L) "am"	-	-	-	15.3	9.6	37.3
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	22.4	36.2	-	12.3	0.9	92.7
TSS (mg/L)	123.0	155.4	-	49.3	5.7	88.4
TDS (mg/L)	46256.0	48464.0	-	47640.0	49660.0	-4.2
TSM (mg/L)"am"	145.4	191.6	-	61.6	6.6	89.3
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 8-Feb-89

Mode: MBM
Operator: PCF

Run Number: **10B**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	-	-	-	89.3	6.0	93.3
TDO (mg/L) "am"	-	-	-	9.7	6.0	38.1
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	-	80.0	0.4	99.5
TSS (mg/L)	-	-	-	285.2	5.0	98.2
TDS (mg/L)	-	-	-	49820.0	49984.0	-0.3
TSM (mg/L)"am"	-	-	-	365.2	5.4	98.5
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 9-Feb-89

Mode: MBM
Operator: PCF

Run Number: 11A

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	34.7	28.0	-	24.0	3.8	84.2
TDO (mg/L) "am"	-	-	-	10.1	3.8	62.4
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	33396.0	32688.0	-	33772.0	34608.0	-2.5
TSM (mg/L)"am"	97.3	71.9	-	35.8	13.5	62.3
TSM (mg/L)"pm"						
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 9-Feb-89

Mode: MBM
Operator: PCF

Run
Number: 11B

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07
OIL						
TO (mg/L) "am"	-	-	-	90.4	6.4	92.9
TDO (mg/L) "am"	-	-	-	10.9	6.4	41.3
TO (mg/L) "pm"	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-
SOLIDS						
Hydrocarbon (mg/L)	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-
TDS (mg/L)	-	-	35108.0	35108.0	35272.0	-0.5
TSM (mg/L)"am"	-	-	251.4	251.1	5.2	97.9
TSM (mg/L)"pm"	-	-	-	-	-	-
IONS						
Ca (mg/L)	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-
PHYSICAL						
Colour (APHA)	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-
pH	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 25-Jul-89

Mode: MBM
Operator: BM

Run Number: **12A**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	243.9	228.5	82.0	91.0	16.0	82.4	36.7	59.7
TDO (mg/L)"am"	-	-	-	15.5	16.0	-3.2	36.7	-136.8
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	269.7	241.2	131.9	162.3	0.5	99.7	0.9	99.4
TSS (mg/L)	161.6	145.7	127.2	171.9	2.9	98.3	3.2	98.1
TDS (mg/L)	6488.0	5116.0	5872.0	5668.0	5500.0	3.0	6288.0	-10.9
TSM (mg/L)"am"	431.3	386.9	259.1	334.2	3.4	99.0	4.1	98.8
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 26-Jul-89

Mode: MBM
Operator: BM

Run
Number: 12B

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	1600.7	252.0	643.1	61.0	15.4	74.8	25.7	57.9
TDO (mg/L)"am"	-	-	-	30.1	15.4	48.8	25.7	14.6
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	368.0	158.5	126.3	1250.8	1.5	99.9	1.8	99.9
TSS (mg/L)	254.3	56.8	73.5	561.5	16.0	97.2	18.0	96.8
TDS (mg/L)	2388.0	2964.0	2912.0	7404.0	7516.0	-1.5	7476.0	-1.0
TSM (mg/L)"am"	622.3	214.5	199.8	1812.3	17.5	99.0	19.8	98.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	43.3	-	-	-	-	-	-	-
Mg (mg/L)	11.8	-	-	-	-	-	-	-
Si (mg/L)	94.8	-	-	-	-	-	-	-
Na (mg/L)	932.0	-	-	-	-	-	-	-
Cl (mg/L)	4460.0	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	<4	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	6.8	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 27-Jul-89

Mode: MBM
Operator: BM

Run
Number: 12C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	275.4	212.4	169.7	830.7	4.3	99.5	13.5	98.4
TDO (mg/L)"am"	-	-	-	6.6	4.3	34.8	13.5	-104.5
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	389.5	368.8	270.0	1044.4	0.0	100.0	0.4	100.0
TSS (mg/L)	64.2	68.4	63.6	850.5	0.0	100.0	1.1	99.9
TDS (mg/L)	3792.0	6140.0	5824.0	4160.0	4032.0	3.1	4036.0	3.0
TSM (mg/L)"am"	453.7	437.2	333.6	1894.9	4.1	99.8	1.5	99.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 28-Jul-89
Mode:
Operator: BM
Run Number: 12D

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	-	-	-	639.8	23.3	96.4	8.7	98.6
TDO (mg/L)"am"	-	-	-	6.7	23.3	-247.8	8.7	-29.9
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	2434.1	2.1	99.9	1.1	100.0
TSS (mg/L)	-	-	-	1141.0	0.7	99.9	0.6	99.9
TDS (mg/L)	-	-	-	6636.0	6108.0	8.0	6484.0	2.3
TSM (mg/L)"am"	-	-	-	3575.0	2.8	99.9	1.7	100.0
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	64.8	-	-	-	116.0	-	112.0	-
Mg (mg/L)	21.9	-	-	-	40.1	-	39.0	-
Si (mg/L)	67.5	-	-	-	93.4	-	92.0	-
Na (mg/L)	1130.0	-	-	-	1860.0	-	1830.0	-
Cl (mg/L)	2030.0	-	-	-	3400.0	-	3400.0	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	<4	-	-	-	<4	-	<4	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	6.8	-	-	-	7.1	-	7.1	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 31-Jul-89

Mode: MBM
Operator: BM

Run Number: 13A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	-	-	-	1506.5	8.4	99.4	12.1	99.2
TDO (mg/L)"am"	-	-	-	8.6	8.4	2.3	12.1	-40.7
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	2178.7	1.1	99.9	0.4	100.0
TSS (mg/L)	-	-	-	1358.8	4.4	99.7	0.7	99.9
TDS (mg/L)	-	-	-	6232.0	5836.0	6.4	5656.0	9.2
TSM (mg/L)"am"	-	-	-	3537.5	5.5	99.8	1.1	100.0
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 1-Aug-89

Mode: MBM
Operator: BM

Run
Number: 14A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HEM-08	% Rej. HEM-08
OIL								
TO (mg/L)"am"	1700.0	116.6	240.5	700.5	25.3	96.4	13.4	98.1
TDO (mg/L)"am"	-	-	-	21.4	25.3	-18.2	13.4	37.4
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	3502.4	103.6	165.8	742.4	0.5	99.9	-	-
TSS (mg/L)	1127.6	265.8	267.9	817.1	1.2	99.9	4.4	99.5
TDS (mg/L)	NA	8952.0	7840.0	13624.0	13492.0	1.0	13484.0	1.0
TSM (mg/L)"am"	4630.0	369.4	433.7	1559.3	1.7	99.9	3.2	99.8
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	247.0	-	-	-	-	-	-	-
Mg (mg/L)	102.0	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	3290.0	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 2-Aug-89

Mode: MBM
Operator: BM

Run Number: **14B**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HEM-08	% Rej. HEM-08
OIL								
TO (mg/L)"am"	857.7	274.5	163.0	1513.2	8.5	99.4	9.0	99.4
TDO (mg/L)"am"	-	-	-	4.6	8.5	-84.8	9.0	-95.7
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	392.4	195.4	170.3	1003.1	-	-	2.0	99.8
TSS (mg/L)	138.6	119.4	126.5	476.9	-	-	4.6	99.0
TDS (mg/L)	33320.0	29500.0	29496.0	23324.0	21564.0	7.5	21324.0	8.6
TSM (mg/L)"am"	531.0	314.8	296.8	1480.0	8.3	99.4	6.6	99.6
TSM (mg/L)"pm"								
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 3-Aug-89

Mode: MBM
Operator: BM

Run Number: 14C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HEM-08	% Rej. HEM-08
OIL								
TO (mg/L)"am"	2930.4	108.4	62.8	1412.0	27.2	98.1	29.0	97.9
TDO (mg/L)"am"	-	-	-	13.3	27.2	-104.5	29.0	-118.0
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	726.5	191.2	138.4	291.2	-	-	0.9	99.7
TSS (mg/L)	87.7	58.0	48.0	162.4	-	-	4.1	97.5
TDS (mg/L)	9744.0	8196.0	8216.0	9996.0	10292.0	-3.0	11860.0	-18.6
TSM (mg/L)"am"	814.2	249.2	186.4	453.6	3.6	99.2	5.0	98.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	216.0	-	254.0	-
Mg (mg/L)	-	-	-	-	87.6	-	104.0	-
Si (mg/L)	-	-	-	-	102.0	-	101.0	-
Na (mg/L)	-	-	-	-	2950.0	-	3460.0	-
Cl (mg/L)	-	-	-	-	5560.0	-	6310.0	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	8.6	-	12.3	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	7.0	-	7.1	-

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 4-Aug-89

Mode:
Operator: BM

Run
Number: 15A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HEM-08	% Rej. HEM-08
OIL								
TO (mg/L)"am"	215.8	43.5	34.6	78.3	9.1	88.4	18.6	76.2
TDO (mg/L)"am"	-	-	-	25.3	9.1	64.0	18.6	26.5
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	55.6	7.6	4.5	153.9	0.5	99.7	1.0	99.4
TSS (mg/L)	174.0	76.2	41.7	37.8	2.4	93.7	1.5	96.0
TDS (mg/L)	24892.0	8776.0	9068.0	8456.0	7932.0	6.2	8020.0	5.2
TSM (mg/L)"am"	229.6	83.8	46.2	191.7	2.9	98.5	2.5	98.7
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	462.0	-	-	-	-	-	-	-
Mg (mg/L)	184.0	-	-	-	-	-	-	-
Si (mg/L)	33.7	-	-	-	-	-	-	-
Na (mg/L)	6330.0	-	-	-	-	-	-	-
Cl (mg/L)	11700.0	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	11.3	-	-	-	-	-	-	-
PHYSICAL	-	-	-	-	-	-	-	-
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	7.7	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"	Mode: MBM	Run
Date: 8-Aug-89	Operator: BM	Number: **15B**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HEM-08	% Rej. HEM-08
OIL								
TO (mg/L)"am"	-	-	-	146.6	8.4	94.3	6.6	95.5
TDO (mg/L)"am"	-	-	-	11.0	8.4	23.6	6.6	40.0
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	164.4	0.5	99.7	1.0	99.4
TSS (mg/L)	-	-	-	278.4	9.0	96.8	6.2	97.8
TDS (mg/L)	-	-	-	10200.0	9322.0	8.6	9484.0	7.0
TSM (mg/L)"am"	-	-	-	442.8	9.5	97.9	7.2	98.4
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 9-Aug-89

Mode: MBM
Operator: BM

Run Number: 16A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HEM-08	% Rej. HEM-08
OIL								
TO (mg/L)"am"	1238.6	21.0	28.5	323.9	4.3	98.7	4.3	98.7
TDO (mg/L)"am"	-	-	-	7.8	4.3	44.9	4.3	44.9
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	350.4	48.3	34.3	278.7	0.5	99.8	0.5	99.8
TSS (mg/L)	165.5	123.5	65.5	397.3	6.7	98.3	3.9	99.0
TDS (mg/L)	18212.0	19056.0	17920.0	17762.0	17684.0	0.4	17672.0	0.5
TSM (mg/L)"am"	515.9	171.8	99.8	676.0	7.2	98.9	4.3	99.4
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	462.0	-	-	-	382.0	-	381.0	-
Mg (mg/L)	184.0	-	-	-	149.0	-	148.0	-
Si (mg/L)	33.7	-	-	-	52.9	-	52.9	-
Na (mg/L)	6330.0	-	-	-	5310.0	-	5240.0	-
Cl (mg/L)	11700.0	-	-	-	9550.0	-	9550.0	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	11.3	-	-	-	12.3	-	13.0	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	7.7	-	-	-	7.6	-	7.5	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 10-Aug-89

Mode: MBM
Operator: BM

Run Number: **16B**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HEM-08	% Rej. HEM-08
OIL								
TO (mg/L)"am"	2881.4	82.0	73.3	976.3	6.0	99.4	5.8	99.4
TDO (mg/L)"am"	-	-	-	6.6	6.0	9.1	5.8	12.1
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L)"pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	4309.4	90.0	87.0	1144.0	0.5	100.0	0.2	100.0
TSS (mg/L)	751.7	90.4	85.0	759.0	2.6	99.7	9.2	98.8
TDS (mg/L)	12880.0	13728.0	13568.0	13656.0	14604.0	-6.9	14440.0	-5.7
TSM (mg/L)"am"	5061.1	180.4	172.0	1903.0	3.1	99.8	9.4	99.5
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 23-Oct-89

Mode: FBM
Operator: BM

Run
Number: **17A**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	2820.3	-	-	37.9	-	-	24.6	35.1
TDO (mg/L)"am"	-	-	-	15.7	-	-	24.6	-56.7
TO (mg/L)"pm"	-	-	-	-	-	-	30.1	-91.7
TDO (mg/L) "pm"	-	-	-	-	-	-	30.1	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	694.5	-	-	204.9	-	-	6	97.1
TSM (mg/L)"pm"	-	-	-	-	-	-	2.1	99.0
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

ZENON ENVIRONMENTAL INC.

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 24-Oct-89

Mode: FBM
Operator: BM

Run Number: 17B

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	247.9	-	-	213.8	27.5	87.1	14.2	93.4
TDO (mg/L)"am"	-	-	-	16.6	27.5	-65.7	14.2	14.5
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	228.9	-	-	725.0	4.4	99.4	5.1	99.3
TSM (mg/L)"pm"	-	-	-	-	-	-	2.1	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 25-Oct-89

Mode: FBM
Operator: BM

Run
Number: 17C

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	1177.3	-	185.3	567.4	25.6	95.5	20.1	96.5
TDO (mg/L)"am"	-	-	-	8.5	25.6	-201.2	20.1	-136.5
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	646.0	-	147.8	1463.0	0.2	100.0	1.3	99.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 26-Oct-89

Mode: FBM
Operator: BM

Run
Number: **18A**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	302.4	-	952.3	496.7	9	98.2	7.8	98.4
TDO (mg/L)"am"	-	-	-	7.8	9	-15.4	7.8	0.0
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	159.7	-	1020.0	1745.8	5.6	99.7	5.5	99.7
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 27-Oct-89

Mode: FBM
Operator: BM

Run
Number: **18B**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	139.8	-	1239.5	1203.0	10.5	99.1	10.2	99.2
TDO (mg/L)"am"	-	-	-	8.8	10.5	-19.3	10.2	-15.9
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	876.4	-	2849.6	1891.0	4.6	99.8	13.4	99.3
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	312.0	-	375.0	370.0	391.0	-5.7	376.0	-1.6
Mg (mg/L)	130.0	-	160.0	156.0	162.0	-3.8	156.0	0.0
Si (mg/L)	38.2	-	38.2	39.7	36.8	7.3	38.2	3.8
Na (mg/L)	4850.0	-	5770.0	5770.0	6190.0	-7.3	5900.0	-2.3
Cl (mg/L)	7850.0	-	10200.0	10200.0	10100.0	1.0	10100.0	1.0
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	69.8	-	57.9	65.5	63.3	3.4	68.2	-4.1
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 30-Oct-89

Mode: FBM
Operator: BM

Run
Number: 18C

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	181.4	-	183.6	296.4	31.4	89.4	8.9	97.0
TDO (mg/L)"am"	-	-	-	18.9	31.4	-66.1	8.9	52.9
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	99.4	-	556.0	606.4	3.8	99.4	4.3	99.3
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 31-Oct-89

Mode: FBM
Operator: BM

Run Number: 18D

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	215.3	-	881.8	846.3	8.3	99.0	12.9	98.5
TDO (mg/L)"am"	-	-	-	17.9	8.3	53.6	12.9	27.9
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	398.0	-	765.7	960.0	10	99.0	18.5	98.1
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 1-Nov-89

Mode: FBM
Operator: BM

Run
Number: 19A

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	69.1	-	147	14.0	15.2	-8.6	4.3	69.3
TDO (mg/L)"am"	-	-	-	3.3	15.2	-360.6	4.3	-30.3
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	210.1	-	195.3	336.7	1.5	99.6	10.5	96.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 2-Nov-89

Mode: FBM
Operator: BM

Run Number: 19B

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	29.9	-	4.4	727.4	2.7	99.6	0.6	99.9
TDO (mg/L)"am"	-	-	-	18.8	2.7	85.6	0.6	96.8
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	182.2	-	174.2	590.0	3.2	99.5	12.8	97.8
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 3-Nov-89

Mode: FBM
Operator: BM

Run
Number: 19C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	57.4	-	14.8	201.5	4.1	98.0	7.7	96.2
TDO (mg/L)"am"	-	-	-	9.1	4.1	54.9	7.7	15.4
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	207.1	-	27.2	234.8	9.8	95.8	8.8	96.3
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	283.0	-	292.0	301.0	281.0	6.6	318.0	-5.6
Mg (mg/L)	122.0	-	126.0	129.0	121.0	6.2	137.0	-6.2
Si (mg/L)	42.6	-	42.6	42.6	42.6	0.0	44.1	-3.5
Na (mg/L)	4580.0	-	4780.0	4880.0	4620.0	5.3	4430.0	9.2
Cl (mg/L)	7590.0	-	7500.0	7670.0	7560.0	1.4	7620.0	0.7
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	80.8	-	80.2	77.4	70.2	9.3	68.8	11.1
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 6-Nov-89

Mode: FBM
Operator: BM

Run Number: **19D**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	27.7	-	-	46.6	7.2	84.5	4.4	90.6
TDO (mg/L)"am"	-	-	-	7.3	7.2	1.6	4.4	39.9
TO (mg/L)"pm"	-	-	-	-	4.5	-	3.4	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	211.2	-	-	228.9	12.5	94.5	14.1	93.8
TSM (mg/L)"pm"	-	-	-	-	3.6	-	3	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 7-Nov-89

Mode: FBM
Operator: BM

Run
Number: 19E

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	37.7	-	-	88.6	6.8	92.3	10.1	88.6
TDO (mg/L)"am"	-	-	-	16.6	6.8	59.0	10.1	39.2
TO (mg/L)"pm"	-	-	-	-	11.6	-	10.7	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	4604.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	242.8	-	-	176.3	8.7	95.1	7.6	95.7
TSM (mg/L)"pm"	-	-	-	-	4.5	-	8.8	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 20-Nov-89

Mode: FBM
Operator: PCF

Run
Number: **20A**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	2282.0	-	-	125.6	13.3	89.4	11.8	90.6
TDO (mg/L)"am"	-	-	-	22.4	13.3	40.6	11.8	47.3
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	13590.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	227.0	-	-	222.3	8.1	96.4	7.1	96.8
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 21-Nov-89

Mode: FBM
Operator: STF

Run Number: **20B**

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	224.3	-	-	9873.9	8.6	99.9	15.7	99.8
TDO (mg/L)"am"	-	-	-	25.2	8.6	65.9	15.7	37.7
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	12990.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	90.0	-	-	281.5	6.9	97.5	3.8	98.7
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL	-	-	-	-	-	-	-	-
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 22-Nov-89

Mode: FBM
Operator: STF

Run Number: 20C

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	202.1	-	-	619.0	17.2	97.2	13.7	97.8
TDO (mg/L)"am"	-	-	-	17.0	17.2	-1.2	13.7	19.4
TO (mg/L)"pm"	-	-	-	-	8.3	-	11.4	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	18530.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	-	-	-	369.4	7.3	98.0	8.7	97.6
TSM (mg/L)"pm"	-	-	-	-	10.8	-	11.4	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B" Mode: FBM Run
Date: 23-Nov-89 Operator: STF Number: 20D

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	116.6	-	-	860.0	13	98.5	17.2	98.0
TDO (mg/L)"am"	-	-	-	11.4	13	-14.0	17.2	-50.9
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	17460.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	71.0	-	-	440.0	8	98.2	5.4	98.8
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	370.0	371	-0.3	364	1.6
Mg (mg/L)	-	-	-	155.0	154	0.6	152	1.9
Si (mg/L)	-	-	-	68.4	69.1	-1.0	67.6	1.2
Na (mg/L)	-	-	-	5540.0	5620	-1.4	5520	0.4
Cl (mg/L)	-	-	-	9000.0	8840	1.8	9100	-1.1
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	41.6	43.2	-3.8	47.2	-13.5
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 24-Nov-89

Mode: FBM
Operator: STF

Run
Number: 20E

PARAMETERS	Source Feed	Prefilter Feed	Processs Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	287.0	-	-	3250.0	15.4	99.5	12.2	99.6
TDO (mg/L)"am"	-	-	-	17.9	15.4	14.0	12.2	31.8
TO (mg/L)"pm"	-	-	-	-	13.2	-	20.1	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	17570.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	112.0	-	-	2420.0	5.6	99.8	15.6	99.4
TSM (mg/L)"pm"	-	-	-	-	7.7	-	8.4	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 27-Nov-89

Mode: FBM
Operator: DJ

Run
Number: 21A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	135.3	-	-	3670.0	17.3	99.5	20.7	99.4
TDO (mg/L)"am"	-	-	-	9.4	17.3	-84.0	20.7	-120.2
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	11630.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	76.0	-	-	4120.0	3.6	99.9	9.2	99.8
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 28-Nov-89

Mode: FBM
Operator: DJ

Run Number: **21B**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	324.0	-	-	1490.0	19.7	98.7	23.6	98.4
TDO (mg/L)"am"	-	-	-	26.8	19.7	26.5	23.6	11.9
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	12340.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	13.0	-	-	5010.0	22.8	99.5	24.2	99.5
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"	Mode: FBM	Run
Date: 29-Nov-89	Operator: DJ	Number: 21C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	326.0	-	-	4020.0	23.5	99.4	12.6	99.7
TDO (mg/L)"am"	-	-	-	8.7	23.5	-170.1	12.6	-44.8
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	9910.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	216.0	-	-	5830.0	16.5	99.7	8.3	99.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 30-Nov-89

Mode: FBM
Operator: DJ

Run Number: 22A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	612.0	-	-	2820.0	12.4	99.6	12.3	99.6
TDO (mg/L)"am"	-	-	-	8.9	12.4	-39.3	12.3	-38.2
TO (mg/L)"pm"	-	-	-	-	13.7	-	12.3	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	7790.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	244.0	-	-	3150.0	2.2	99.9	2	99.9
TSM (mg/L)"pm"	-	-	-	-	21	-	25	-
IONS								
Ca (mg/L)	-	-	-	179.0	170.0	5.0	173.0	3.4
Mg (mg/L)	-	-	-	53.7	63.7	-18.6	65.1	-21.2
Si (mg/L)	-	-	-	67.6	73.5	-8.7	70.6	-4.4
Na (mg/L)	-	-	-	2870.0	2870.0	0.0	2910.0	-1.4
Cl (mg/L)	-	-	-	4880.0	4500.0	7.8	4640.0	4.9
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	60.2	54.9	8.8	57.2	5.0
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 5-Dec-89

Mode: FBM
Operator: DJ

Run
Number: 22B

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	225.0	-	-	1310.0	18.9	98.6	17.1	98.7
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	10680.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	262.0	-	-	2500.0	9.7	99.6	20.1	99.2
TSM (mg/L)"pm"	-	-	-		10.4	-	13.1	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-		-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 6-Dec-89

Mode: FBM
Operator: DJ

Run Number: 22C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HSC-04	% Rej. HSC-04
OIL								
TO (mg/L)"am"	329.0	-	-	2930.0	8.2	99.7	17.3	99.4
TDO (mg/L)"am"	-	-	-	5.4	8.2	-51.9	17.3	-220.4
TO (mg/L)"pm"	-	-	-	-	5.6	-	7.6	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	4250.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	263.0	-	-	7220.0	12.8	99.8	11.7	99.8
TSM (mg/L)"pm"	-	-	-	-	11	-	16.6	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B" Mode: FBM Run
Date: 7-Dec-89 Operator: DJ Number: 23A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	73.9	-	-	1610.0	11.8	99.3	14.9	99.1
TDO (mg/L)"am"	-	-	-	6.7	11.8	-76.1	14.9	-122.4
TO (mg/L)"pm"	-	-	-	-	15.4	-	15.1	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	42570.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	109.0	-	-	2190.0	3.8	99.8	3.5	99.8
TSM (mg/L)"pm"	-	-	-	-	10.8	-	7.6	-
IONS								
Ca (mg/L)	-	-	-	110.0	103.0	6.4	105.0	4.5
Mg (mg/L)	-	-	-	44.2	39.3	11.1	40.1	9.3
Si (mg/L)	-	-	-	47.2	43.4	8.1	41.9	11.2
Na (mg/L)	-	-	-	1880.0	1890.0	-0.5	1900.0	-1.1
Cl (mg/L)	-	-	-	2930.0	2920.0	0.3	2930.0	0.0
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	86.0	80.1	6.9	86.3	-0.3
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 8-Dec-89

Mode: FBM
Operator: DJ

Run Number: 23B

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	317.0	-	-	1040.0	7.7	99.3	7.8	99.3
TDO (mg/L)"am"	-	-	-	8.9	7.7	13.5	7.8	12.4
TO (mg/L)"pm"	-	-	-	-	12.1	-	12.4	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	265.0	-	-	1920.0	16.6	99.1	22.8	98.8
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 11-Dec-89

Mode: FBM
Operator: DJ

Run
Number: 23C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	-	-	-	735.0	16.7	97.7	24.0	96.7
TDO (mg/L)"am"	-	-	-	6.8	16.7	-145.6	24.0	-252.9
TO (mg/L)"pm"	-	-	-	-	24.3	-	21.8	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"		-	-	1290.0	3.0	99.8	2.9	99.8
TSM (mg/L)"pm"	-	-	-	-	17.1	-	17.8	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 12-Dec-89

Mode: FBM
Operator: DJ

Run Number: 23D

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	123.0	-	-	995.0	21.1	97.9	17.3	98.3
TDO (mg/L)"am"	-	-	-	14.1	21.8	-54.6	17.3	-22.7
TO (mg/L)"pm"	-	-	-	-	11.8	-	10.5	-
TDO (mg/L) "pm"	-	-	-	-	11.8	-	10.5	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	7620.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	113.0	-	-	1240.0	5.7	99.5	8.4	99.3
TSM (mg/L)"pm"	-	-	-	-	3.0	-	3.9	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 14-Dec-89

Mode: FBM
Operator: DJ

Run
Number: 24A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	205.0	-	-	914.0	10.3	98.9	13.2	98.6
TDO (mg/L)"am"	-	-	-	11.8	10.3	12.7	13.2	-11.9
TO (mg/L)"pm"	-	-	-	-	10.7	-	14.1	-
TDO (mg/L) "pm"	-	-	-	-	10.7	-	14.1	-
								-
SOLIDS								-
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	9010.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	125.0	-	-	2130.0	2.2	99.9	5.9	99.7
TSM (mg/L)"pm"	-	-	-	-	8.9	-	7.1	-
								-
IONS								-
Ca (mg/L)	-	-	-	149.0	166.0	-11.4	137.0	8.1
Mg (mg/L)	-	-	-	46.3	63.5	-37.1	32.5	29.8
Si (mg/L)	-	-	-	56.4	60.9	-8.0	54.0	4.3
Na (mg/L)	-	-	-	3090.0	3060.0	1.0	3090.0	0.0
Cl (mg/L)	-	-	-	4780.0	4730.0	1.0	4700.0	1.7
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	96.7	85.0	12.1	81.4	15.8
								-
								-
PHYSICAL								-
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 15-Dec-89

Mode: FBM
Operator: DJ

Run Number: **24B**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	103.0	-	-	339.0	4.4	98.7	4.4	98.7
TDO (mg/L)"am"	-	-	-	5.8	4.4	24.1	4.4	24.1
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	81.0	-	-	4340.0	4.3	99.9	4.5	99.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B" Mode: FBM Run
Date: 19-Dec-89 Operator: DJ Number: 24C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	194.0	-	-	598.0	5.8	99.0	5.5	99.1
TDO (mg/L)"am"	-	-	-	11.6	4.1	64.7	2.7	76.7
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	8140.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	203.0	-	-	6840.0	3.8	99.9	4.4	99.9
TSM (mg/L)"pm"	-	-	-	-	3.0	-	3.8	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 20-Dec-89

Mode: FBM
Operator: DJ

Run Number: 24D

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HST-04	% Rej. HST-04
OIL								
TO (mg/L)"am"	319.0	-	-	761.0	8.5	98.9	4	99.5
TDO (mg/L)"am"	-	-	-	4.1	8.5	-107.3	4	2.4
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	8452.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	150.0	-	-	9400.0	1.7	100.0	3.9	96.1
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 10-Jan-90

Mode: FBM
Operator: BM

Run Number: 25A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HEM-09	% Rej. HEM-09
OIL								
TO (mg/L)"am"	775.0	-	-	1810.0	13.1	99.3	16.2	99.1
TDO (mg/L)"am"	-	-	-	10.0	13.1	-31.0	16.2	-62.0
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	22960.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	121.0	-	-	2790.0	0.7	100.0	1.9	99.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	200.0	-	191.0	-
Mg (mg/L)	-	-	-	-	57.6	-	55.2	-
Si (mg/L)	-	-	-	-	54.9	-	51.9	-
Na (mg/L)	-	-	-	-	3900.0	-	3930.0	-
Cl (mg/L)	-	-	-	-	5270.0	-	5500.0	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	83.4	-	70.3	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 11-Jan-90

Mode: FBM
Operator: BM

Run
Number: **25B**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate HEM-09	% Rej. HEM-09
OIL								
TO (mg/L)"am"	349.0	-	167	1720.0	13.7	99.2	10.9	99.4
TDO (mg/L)"am"	-	-	-	9.9	13.7	-38.4	10.9	-10.1
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	12300.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	259.0	-	97.0	4340.0	3.6	99.9	5.7	99.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"	Mode: FBM	Run
Date: 11-Jan-90	Operator: BM	Number: 26A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate -	% Rej. -
OIL								
TO (mg/L)"am"	349.0	-	-	1720.0	10.0	99.4	-	-
TDO (mg/L)"am"	-	-	-	9.9	-	-1.0	-	-
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	259.0	-	-	4340.0	11.1	99.7	-	-
TSM (mg/L)"pm"								
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 12-Jan-90

Mode: FBM
Operator: BM

Run Number: **26B**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate -	% Rej. -
OIL								
TO (mg/L)"am"	254.0	-	-	2080.0	9.2	99.6	-	-
TDO (mg/L)"am"	-	-	-	16.1	7.5	53.4	-	-
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	470.0	-	-	6730.0	10.6	99.8	-	-
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL	-	-	-	-	-	-	-	-
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 15-Jan-90

Mode: FBM
Operator: BM

Run
Number: **26C**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-07	% Rej. HEM-07	Permeate -	% Rej. -
OIL								
TO (mg/L)"am"	669.0	-	-	1030.0	3.3	99.7	-	-
TDO (mg/L)"am"	-	-	-	2.2	3.5	-59.1	-	-
TO (mg/L)"pm"	-	-	-	1030.0	5.9	99.4	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	1150.0	-	-	-	-
TSS (mg/L)	-	-	-	4180.0	-	-	-	-
TDS (mg/L)	6208.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	553.0	-	-	5330.0	19.6	99.6	-	-
TSM (mg/L)"pm"	-	-	-	-	22.1	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 23-Jan-90

Mode: FBM
Operator: BM

Run Number: 29A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	295.0	-	-	403.0	13.9	96.6	-	-
TDO (mg/L)"am"	-	-	-	6.6	5.1	22.7	-	-
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	312.0	-	-	-	-
TSS (mg/L)	-	-	-	104.0	-	-	-	-
TDS (mg/L)	7904.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	209.0	-	-	416.0	8.4	98.0	-	-
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 24-Jan-90

Mode: FBM
Operator: BM

Run Number: 29B

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	473.0	-	223	645.0	21.4	96.7	21.7	96.6
TDO (mg/L)"am"	-	-	-	13.9	19.3	-38.8	20.1	-44.6
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	440.0	-	-	-	-
TSS (mg/L)	-	-	-	24.0	-	-	-	-
TDS (mg/L)	6096.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	350.0	-	106.0	464.0	2.5	99.5	4.8	99.0
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	148.0	-	144.0	-
Mg (mg/L)	-	-	-	-	60.8	-	60.7	-
Si (mg/L)	-	-	-	-	41.2	-	43.8	-
Na (mg/L)	-	-	-	-	48.8	-	2610.0	-
Cl (mg/L)	-	-	-	-	3800.0	-	3900.0	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	11.0	-	68.6	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 26-Jan-90

Mode: FBM
Operator: BM

Run
Number: **30A**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	170.0	-	-	294.0	18.0	93.9	32.1	89.1
TDO (mg/L)"am"	-	-	-	13.0	19.2	-47.7	16.6	-27.7
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	67.0	-	-	-	-
TSS (mg/L)	-	-	-	2.0	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	459.0	-	-	69.0	0.6	99.1	5.0	92.8
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 27-Jan-90

Mode: FBM
Operator: BM

Run Number: **30B**

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	770.0	-	-	41.0	19.9	51.5	29.3	28.5
TDO (mg/L)"am"	-	-	-	9.6	14.8	-54.2	13.6	-41.7
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	153.0	-	-	41.0	8.5	79.3	8.2	80.0
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 29-Jan-90

Mode: FBM
Operator: BM

Run Number: 30C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	5050.0	-	-	88.0	16.1	81.7	17.9	79.7
TDO (mg/L)"am"	-	-	-	9.8	12.4	-26.5	11.6	-18.4
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	1670.0	-	-	57.0	1.8	96.8	2.9	94.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 29-Jan-90

Mode: FBM
Operator: BM

Run Number: 31A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	5050.0	-	-	88.0	13.0	85.2	156	-77.3
TDO (mg/L)"am"	-	-	-	9.8	-	-	-	-
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	1670.0	-	-	57.0	1.3	97.7	145.0	-154.4
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 30-Jan-90

Mode: FBM
Operator: BM

Run Number: 31B

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	966.0	-	-	381.0	16.9	95.6	126.0	66.9
TDO (mg/L)"am"	-	-	-	14.9	14.7	1.3	17.3	-16.1
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	4948.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	1180.0	-	-	266.0	1.3	99.5	103.0	61.3
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	179	-	184	-
Mg (mg/L)	-	-	-	-	77.4	-	78.7	-
Si (mg/L)	-	-	-	-	46.3	-	51.6	-
Na (mg/L)	-	-	-	-	3060	-	3090	-
Cl (mg/L)	-	-	-	-	4070	-	4180	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	227	-	240	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 31-Jan-90

Mode: FBM
Operator: BM

Run
Number: 31C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	865.0	-	622	238.0	13.6	94.3	133.0	44.1
TDO (mg/L)"am"	-	-	-	14.4	17.1	-18.8	8.4	41.7
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	440.0	-	378.0	214.0	13	93.9	116.0	45.8
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH.	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 31-Jan-90

Mode: FBM
Operator: BM

Run
Number: 32A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	865.0	-	622.0	238.0	23.5	90.1	301	-26.5
TDO (mg/L)"am"	-	-		14.4	-	-	-	-
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	440.0	-	378.0	214.0	12.1	94.3	284.0	-32.7
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 1-Feb-90

Mode: FBM
Operator: BM

Run
Number: 32B

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	1030.0	-	-	2200.0	11	99.5	762.0	65.4
TDO (mg/L)"am"	-	-	-	13.8	14.8	-7.2	12.1	12.3
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	919.0	-	-	956.0	1.2	99.9	555.0	41.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 2-Feb-90

Mode: FBM
Operator: BM

Run Number: 32C

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	664.0	-	-	3110.0	17	99.5	233.0	92.5
TDO (mg/L)"am"	-	-	-	14.5	11.2	22.8	12.1	16.6
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	1167.0	-	-	-	-
TSS (mg/L)	-	-	-	93.0	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	553.0	-	-	1260.0	6.8	99.5	304.0	75.9
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 2-Feb-90
Mode: FBM
Operator: BM
Run Number: 33A

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	664.0	-	-	3110.0	25.9	99.2	862	72.3
TDO (mg/L)"am"	-	-	-	14.5	-	-	-	-
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	1242.0	-	-	-	-
TSS (mg/L)	-	-	-	18.0	-	-	-	-
TDS (mg/L)	-	-	-	-	-	-	-	-
TSM (mg/L)"am"	553.0	-	-	1260.0	3.1	99.8	700.0	44.4
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

File No. C0874073

PRODUCED WATER ULTRAFILTRATION FIELD TESTING

Site: "B"
Date: 5-Feb-90

Mode: Feed and Bleed
Operator: BM

Run
Number: 33B

PARAMETERS	Source Feed	Prefilter Feed	Process Feed	Membrane Feed	Permeate HEM-08	% Rej. HEM-08	Permeate HST-05	% Rej. HST-05
OIL								
TO (mg/L)"am"	657.0	-	-	172.0	16.5	90.4	81.6	52.6
TDO (mg/L)"am"	-	-	-	9.3	11.7	-25.8	7.6	18.3
TO (mg/L)"pm"	-	-	-	-	-	-	-	-
TDO (mg/L) "pm"	-	-	-	-	-	-	-	-
SOLIDS								
Hydrocarbon (mg/L)	-	-	-	-	-	-	-	-
TSS (mg/L)	-	-	-	-	-	-	-	-
TDS (mg/L)	4780.0	-	-	-	-	-	-	-
TSM (mg/L)"am"	370.0	-	-	112.0	8.3	92.6	292.0	-160.7
TSM (mg/L)"pm"	-	-	-	-	-	-	-	-
IONS								
Ca (mg/L)	-	-	-	-	-	-	-	-
Mg (mg/L)	-	-	-	-	-	-	-	-
Si (mg/L)	-	-	-	-	-	-	-	-
Na (mg/L)	-	-	-	-	-	-	-	-
Cl (mg/L)	-	-	-	-	-	-	-	-
HCO3 (mg/L)	-	-	-	-	-	-	-	-
SO4 (mg/L)	-	-	-	-	-	-	-	-
PHYSICAL								
Colour (APHA)	-	-	-	-	-	-	-	-
Resistivity (ohms)	-	-	-	-	-	-	-	-
Refractive Index	-	-	-	-	-	-	-	-
Relative Density	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-

ANALYTICAL RESULTS REPORT

CLIENT INFORMATION
Name: PEG-EMR-PWM
Project: CO884073

LAB INFORMATION
Contact: SDH
Project: AN908890
Date: Apr.24 1990

Notes: "–" = Not Analysed
"<" = Less than MDL

		Client ID:	FOULANT-1	FOULANT-1
		Lab ID:	007180 90	007180 90 Duplicate
Component	**MDL**	**Units**		
Loss on Ignition	100	mg/kg	280000	–
Calcium	20	mg/kg	58000	58000
Magnesium	40		110000	110000
Sodium	50		15000	15000
Potassium	100		670	620
Aluminum	30		6900	6900
Barium	0.2		1700	1600
Beryllium	0.1		0.3	0.3
Boron	10		370	360
Cadmium	0.2		<	0.3
Chromium	5		13	14
Cobalt	5		<	<
Copper	5		10	10
Iron	5		2100	2200
Lead	10		<	<
Manganese	5		480	470
Molybdenum	5		<	<
Nickel	5		17	290
Phosphorus	50		8900	8900
Silicon	10		2700	3100
Silver	5		<	<
Strontium	0.1		2800	2800
Sulphur	10		5500	4800
Thallium	20		<	34
Titanium	5		32	28
Vanadium	10		36	36
Zinc	5		98	100
Zirconium	5		<	<

APPENDIX E

Analytical Methods

1) CHLORIDE AND SULFATE

Method:

- ASTM D4327-84 - Anions in Water by Anion Chromotography

Instrumentation:

- Dionex 2120i Ion Chromotograph
- Aution 100 System Controller
- AS4A Chromotograph Column
- Hewlett Packard 339OA Integrator
- Hamilton Diluter

Summary:

- Samples are filtered through 0.45 μm. cartridges and diluted as needed to reduce ionic strength to within the limits of the chromotograph column. The integrator determines the concentration of anions in the sample compared with external standard calibration data.

2) ALKALINITY (pH, Carbonate, Bicarbonate, Hydroxide)

Method:

- Standard Methods for the Examination of Water and Wastewater #403, 16th Edition, pp 269-273.

Instrumentation:

- Metrohm Potentiograph E536
- Metrohm Dosimat E535

Summary:

- Sample aliquots are automatically titrated with 0.1N HCl. Endpoint volumes are recorded at pH 8.36 and at pH 4.00.

3) RELATIVE DENSITY

Method:

- Standard Methods for the Examination of Water and Wastewater #210B, 16th Edition, pp 102-108.

Apparatus:

- Fish Hydrometers
- Thermometer

Summary:

- The hydrometer is placed in the filtered sample. A reading is taken to the nearest 0.0005. The temperature of the sample is recorded at the time of the hydrometer reading.

4) RESISTIVITY

Method:

- Standard Methods for the Examination of Water and Wastewater #205, 16th Edition, pp 76-80.

Instrumentation:

- YSI Scientific Model 34 Conductance - Resistance Meter
- Calibrated Pipet-type Conductivity Cell.

Summary:

- The cell is rinsed and filled with filtered sample. The instrument displays resistance for the sample solution. Cell constant values and sample temperature are then used to determine resistivity at 25° C.

5) TOTAL OIL (TO)

Method:

- Standard Method, 15th ED. 1980 p. 60 (Revised), Naquadat No. 06521L

Preservation:

- None

Reagents:

- Methylene Chloride
- Sodium sulfate anhydrous
- Sodium chloride

Apparatus:

- 500 ml Graduated separatory funnels
- Small glass frit funnels (30 ml capacity, coarse)
- Clamps and stands
- Aluminum dishes
- Hot plate
- Eye dropper
- Desiccator

- Drying oven - 104C
- Filtering apparatus & Buchner funnel (for soluble O & G only)
- #5 Whatman filter paper (for soluble O & G only)
- 0.45µ Membranes and filtering apparatus (for soluble O & G only)
- Sonic bath

Procedure:

Total Oil and Grease

- Remove numbered aluminum dishes from oven, cool in dessicator for 15 minutes.
- Weigh dish to 4 decimal places and record weight.
- Set up stands with clamps.
- Put 5 g sodium sulfate in each glass frit.
- Position separatory funnel over frit so no methylene chlroride will splash when funnel is drained.
- Place aluminum dish below glass frit to catch methylene chloride layer as it is filtered.
- Pour sample into separatory funnel (Make sure stop clock is closed). Do not discard sample bottle yet.
- Using eye dropper, wet sodium sulfate in glass frit with methylene chloride.
- RECORD VOLUME of water in separatory funnel!
- Pour 10 mix methylene chloride in sample bottle. Cap and shake gentle to rinse off sides as best as possible.
- Add a scoop of sodium chloride.
- Shake sample GENTLY (if sample is shaken too hard an emulsion forms that may be impossible to break) - Venting often in the fume hood.
- If an emulsion forms carefully place separatory funnel in sonic bath. Remove stopper and sonicate for a few minutes **CAUTION** Do not allow sample to sonicate too

long as the methylene chloride will heat up and begin to evaporate and cause a build up of pressure in funnel.

- If emulsion still exists add another 10 mL methylene chloride and gently swirl. sample.
- Once the emulsion is broken drain the methylene chloride layer through the glass frit. containing the sodium sulfate into a pre-weighed aluminum dish.
- Ensure no water filters into dish - If water gets into dish it can be removed by a small piece of paper towel or by using an eye dropper.
- Add 10 mls methylene chloride to sample and repeat as above.
- Repeat until a total of 4 extractions are done.
- Place aluminum dishes on hot plate covered with Zetex cloth (**low** heat, in fume. hood) To evaporate the methylene chloride - - DO NOT BOIL.
- When just dry, remove from hot plate (using tweezers) and place dishes in a. desiccator to cool for 15 minutes.
- Reweigh aluminum dish - Record weight.
- Make sure there are numbered aluminum dishes in drying oven for the next time.

6) TOTAL DISSOLVED OIL (TDO)

Situation A:

If sample appears to have a lot of solids:

1) Set up filtering flask and Buchner Funnel.
2) Use a Whatman #5 filter paper in funnel.
3) Turn on vacuum.
4) Shake sample well.
5) Filter all of sample through filter paper -- filter paper may pug off and have to be changed.
6) Continue with part B below.

Situation B:

If sample appears to have few solids or has been filtered as in part A above:

1) Set up millipore filtering apparatus using 300 mL funnel & 0.45 μ nylon membranes.

2) Turn on vacuum.

3) Filter sample or filtrate from part A through membrane. Membrane will need periodic changing as it plugs up.

- After sample is filtered the filtrate will be analyzed for soluble oil. The membranes, filter paper and original sample bottle are no longer needed and can be discarded.
- Set up apparatus as in procedure for total oil and grease.
- Follow the same procedure as used for total oil and grease.

Omit rinsing original sample bottle with methylene chloride as the oil on the sample bottle is not considered soluble oil.

i.e. Add the first portion of methylene chloride directly to the sample filtrate to be anlyzed- - still perform a total of 4 extractions.

7) TOTAL SUSPENDED MATTER (TSM)

Preservation:

- None in glass

Apparatus:

- Large taped battery jar or large vacuum flask.
- Millipore glass funnel (300 mL) Cat. No. 1004704
- Millipore glass base w/stopper Cat. No. 1004702
- Millipore anodized aluminum spring clamp CAt. No. 1004703

- Millipore forceps Cat. No. 6200006
- 0.45µ (47 mm) Millipore filter membranes Cat. No. Hawp 04700
- Or 5.0µ (47mm) Millipre filter membranes Cat. No. SMWP 04700
- (Or use the nylon filter membranes (47 mm) from Fisher Scientific if the millipore acetate filters cannot be used due to the nature of the sample - 0.45µ Cat. No. N04SP04700 Order from 5.0µ Cat. No. N50SP04700 Fisher Scientific)
- Millipore disposable petri dishes Cat. No. PD 1004700
- Vacuum pump or in house vacuum.
- Analytical balance (4 decimal places)
- 18.5 cm Whatman filter paper (any size may be used if few samples are run)
- Desiccator with desiccant
- 1L graduated cylinder
- Drying oven set ~100°C

Procedure:

Preparation of Filter Membranes

- Place new filter membranes on filter paper. Place another filter paper on top of the membranes.
- Place filter papers and membranes in oven ~100 °C overnight. Be sure to place a weight on top of the membranes as this will prevent them from curling up.
- Remove membranes next morning and cool in desiccator for 1 hour.
- Weigh each membrane accurately to 4 decimal places and place membrane in a petri dish. Record the weight on a piece of tape placed on the dish (be sure to also record the size of the membrane e.g. 0.45µ). Membranes can now be stored for future use.

8) TOTAL SUSPENDED SOLIDS (TSS)

Apparatus:

- Large taped battery jar or large vacuum flask.
- Millipore glass funnel (300 ml) Cat. No. 1004704
- Millipore glass base w/stopper Cat. No. 1004702
- Millipore anodized aluminum spring clamp CAt. No. 1004703
- Millipore forceps Cat. No. 6200006
- 0.45µ (47 mm) Millipore filter membranes Cat. No. Hawp 04700
- Or 5.0µ (47mm) Millipre filter membranes Cat. No. SMWP 04700
- (Or use the nylon filter membranes (47 mm) from Fisher Scientific if the millipore acetate filters cannot be used due to the nature of the sample - 0.45µ Cat. No. N04SP04700 Order from 5.0µ Cat. No. N50SP04700 Fisher Scientific)
- Millipore disposable petri dishes Cat. No. PD 1004700
- Vacuum pump or in house vacuum.
- Analytical balance (4 decimal places)
- 18.5 cm Whatman filter paper (any size may be used if few samples are run)
- Desiccator with desiccant
- 1L graduated cylinder
- Drying oven set ~100°C

Procedure:

- The dried filter remaining after the determination of the Total Suspended Matter is placed in the filter apparatus again and washed with MeCl. This filter is then dried and weighed giving the Total Suspended Solids.

9) HYDROCARBON

- This is a calculated number using the following formula.

Hydrocarbon Content = TSM - TSS

10) TOTAL DISSOLVED SOLIDS (TDS) AND TOTAL DISSOLVED OIL (TDO)

- Weigh crucible (W_1)
- Transfer all filtrate from TSS + TSO determination of known volume (V) to crucible
- Dry crucible overnight at 60°C, dessicate, and weigh (W_2)
- Ash residual in crucible. Muffle for 1 hour at 450°C
- Dessicate and weigh crucible (W_3)
- Calculations:

$TDO = (W_2 - W_3)/V$ $TDS = (W_3 - W_1)/V$

11) LOSS ON IGNITION (L.O.I.)

- 1.5 g of sample is placed in a predried and preweighed evaporating dish. The sample is allowed to dry overnight to constant mass.
- The sample of evaporating dish are then transferred to a cool muffle furnace. Furnace is brought to 550° ± 50°C and sample is left at this temperature for 1 hour.
- Sample is cooled in dessicator to balance temperature and weighed.

$$\text{Loss on Ignition} = \frac{(A-D) * (1{,}000{,}000)}{A-B}$$

where A = weight of dried residue + dish, g

B = weight dish, g

D = weight of residue + dish after igniting, g

12) ZENON SPECTRAL ANALYSIS

- Samples are air dried, ground and sieved to a particle size of 300 µm (5 - 10 g)
- The homogenized sample is then digested using aqua regia via sealed teflon bombs in a microwave. Sealed teflon bombs eliminate the possibility of volatile metals being lost.
- The resulting solution is then analysed for metals by Inductively Coupled Argon Plasma Atomic Emission Spectroscopy (ICAP-AES) using a Jarrell Ash ICAP 61 which is a simultaneous instrument.

13) SITE A - SPECTRAL ANALYSIS

- Calcium, magnesium, barium, aluminum, silicon, and iron were analysed using flame atomic absorption techniques. All elements are analysed with a nitrous oxide/acetylene flame with the exception of iron which is analysed with an air/acetylene flame. Wavelengths and detection limits used for each element are listed below:

Element	Wavelength (NM)	Detection Limit (ppm)
Ca	422.4	0.1
Mg	202.6	0.1
Ba	553.5	0.5
Al	309.4	0.5
Si	251.6	0.5
Fe	248.3	0.05

- All elements were reported in their elemental state with the exception of silicon which is reported as silica (SiO_2). To convert from the measured Si value to SiO_2 we use a multiplicative conversion factor of 2.14.

14) REFRACTIVE INDEX

Instrument:

- Abbe Refractometer - Abbee Mark II

Procedure:

- Turn mode selector to density setting
- Pour a few mL of sample onto prism
- Close prism until it snaps into position
- Looking through the eyepiece, adjust compensator dial to obtain the sharpest line and line up the cross hairs with the black line
- Push read display button
- Record reading
- Push temperature display button
- Record reading
- To clean prisms, rinse with ethanol and dry with kimwipe
- Store prisms shut with a kimwipe between the two surfaces
- Turn off refractometer

Note: Most water samples are in the vicinity of 1.33.

15) COLOUR

- Colour was measured using a Hach Colour Test Kit, Model CO1, using the method outlined in the test kit. Samples were diluted as required to obtain colour in the range measureable with the test kit. The units measured are apparent colour in APHA Platinum Cobalt Units.

16) DETERMINATION OF INORGANIC FOULANT

Method:

- Standard Methods for the examination of Water and Wastewater 16th Edition. Fixed and Volatile Solids Ignited at 550°C - 209D, pp. 97-98.

Apparatus:

- Crucibles
- Analytical Balance - 4 decimal places
- Scissors

Preparation:

- A preweighed section of the membrane is cut up and subjected to the analysis

Summary:

- The analysis is completed in duplicate.

17) DETERMINATION OF OIL BASED FOULANT

Method:

- Soxhlet extraction using hexane

Apparatus:

- Soxhlet extraction apparatus
- Nitrogen blow down apparatus
- Filter apparatus
- Analytical balance - 4 decimal places

Preparation:

- A preweighed representative section of the membrane is cut into thin rings to ensure the soxhlet apparatus does not become plugged.

Summary:

- 500 mls of hexane are added and the material is allowed to reflux for 36 hours. The resultant material is then filtered through a preweighed GF/C paper. This is then weighed to determine the solids content. The filtrate is then blown down with nitrogen and weighed giving the mass of O&G present. Analysis is completed in duplicate.

18) DETERMINATION OF ORGANIC ACID FOULANT

Method:

- Static extraction using 5 N NaOH.

Apparatus:

- 500 ml beakers
- 1 litre volumetric flask

Preparation:

- A 5N NaOH solution is prepared and representative sections of membrane are cut up.

Summary:

- The preweighed membrane sections are added to a 500 ml beaker of 5N NaOH and allowed to sit for 72 hours. The NaOH extract is then filtered through a GF/C filter paper and the filtrate is transferred to a 2L separatory funnel. The pH of the solution is then lowered to 2.0 using HCl. The filtrate is extracted with dichloromethane and filtered through sodium thiosulphate.

The resultant filtrate is then evapoartated in a rotovap. If colour is present after the NaOH extraction but not after the dichloromethane extraction, then organic acid can be said to be present.

APPENDIX F

Emulsion Characterisation

TABLE F-1

Site "A," Skim Tank Influent Produced Water Characteristics With Changes in pH and Heat.

	TIME (hours)			
pH	1	5	24	FINAL (1 week)
Control (pH=8.05)	-brownish opaque solution; some suspended particles visible	- some settling of solids ; slightly darker in colour	- fully settled (0.5 in. layer of solids on bottom) ; darker in colour	- vey dark in colour ; some some loss of volume due to evaporation
10	- some ppt.; essentially no change	- slightly more ppt. than control ; darker orange in colour	- no change except that it is darker in colour	-very similar to control except for a brown residue film floating on top
7.5	- no change	- slightly more ppt. than control ; darker in colour	- no change except that it turned the same colour as control	- same as above
5.5	- no change	- slightly more ppt. than ; same colour as control	- more ppt. than control ;still some suspended floc. ; lighter colour than control	- same as above
4.5	- lighter colour ; suspended floc.; fair degree of settling	- fine floc. ; lighter in colour than control ; same amt. ppt. as " 5.5 "	- lighter colour than " 5.5 " ; still some suspended floc.	- clear with a brownish tinge ; fully settled
3.5	- same as above except for a larger floc. and slightly more ppt.	-lighter still in colour ; same amt. of ppt. as " 4.5 " ; more settled	-lighter colour than " 4.5 " ; almost clear ; little floc. ; bubbles on top	- clear ; greenish brown ppt. settled on bottom
3.3	- same as above except for a still larger floc. and slighty more ppt.	- same as above except for a slightly larger amt. of ppt.	- same as above except for slightly more suspended floc.	- same as above
2.9	- same as above	- same as above except for a heavier floc.	- same as above except for slightly more turbid ; heavier floc.	- same as above
2.5	- same as above except for more floc. and lighter in turbulence	- same as above	- same as above	- same as above

SAMPLES RECEIVED : The samples received were 3, 45 gal. drums of produced water from Site "A" (brown water with suspended solids and grease floating on top) and 2, 45 gal. drums of crude oil (black, heavy, bituminus solution).

pH ADJUSTMENT: ACID - HCL, BASE - NaOH

ADDITION : The heat stability of the produced water sample was also test The sample was heated at 100 °C. for 5 hours. There was no apparent change in the characteristics of the solution except for an oil slick forming on the top of the solution.

June 8, 1988

Zenon Environmental Inc.
845 Harrington Court
Burlington, Ontario
L8N 3P3

Attention: Ms. Heather Donison

Report No. 88-48-50006-042

Identification: Letter of authorization dated May 30, 1988

Specifications of Order: Particle Size Analysis and Zeta Potential on 2 Emulsion Samples provided.

EXPERIMENTAL

Two emulsion samples were submitted to Ontario Research Foundation on May 30, 1988. Sample #1 was described as an "oil-in-water emulsion" with 2500 mg/L of total oil and 500 mg/L suspended solids. Sample #2 was described as a "water-in-oil emulsion" with a water content of 50,000 mg/L

ONTARIO**RESEARCH**
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The particle size analyses were carried out according to the appended report from our Fine Particle Analysis Group, and photomicrographs were taken of each of them.

The zeta potential was measured by the microelectrophoresis method on a Lazer Zee Meter, Model 500. Unfortunately, sample 2 was too viscous to use in the cell and too opaque to be able to transmit the laser light, so a reading was unable to be made.

RESULTS

The results of the particle size analysis are detailed in the appended report and histograms. In summary: (in microns)

	Sample #1	Sample #2
Average	2.1	2.5
RMS Deviation	1.3	1.5
Median	1.8	2.3
Range	0.7-9	0.7-15

The Zeta potential on sample #1 was measured as -35.6 mev with a standard deviation of 1.3. The pH of this particular sample was 8.2.

R. Copley

R. Copley, B.Sc.
Forest Products Services
Energy & Environmental
Engineering Division

RC/vp

Enc.

RESEARCH

[illegible]

Mr. R. A. Copley
Dept. BCE

June 5, 1988

REPORT NUMBER IA 214-88-1

IDENTIFICATION W.O.# 29988

SPECIFICATIONS OF ORDER Particle Size Analysis of Oil & Water Emulsions

---

1. INTRODUCTION

A sample identified as "#1 oil-in-water emulsion" was received for size distribution of the oil droplets. The sample was described as containing 2500 mg of oil per litre and 400 mg of suspended solids per litre.

Another sample identified as "32 water-in-oil emulsion" was also received for size distribution of the water droplets. The sample contained 50,000 mg of water per litre and an unknown quantity of suspended solids.

Representative photomicrographs were also required for each sample.

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6. WE RESERVE THE RIGHT NOT TO COMMENCE AND/OR DISCONTINUE ANY WORK UNTIL PAYMENT ARRANGEMENTS SATISFACTORY TO US ARE ESTABLISHED.

2. METHOD

Sample #1 was shaken and several drops were transferred by pipet from the container to a microscope slide and a coverslip was set on top.

A drop of sample #2 was transferred from the sample container to a microscope slide by pipet and a coverslip was set on top. The droplet was allowed to settle out under the coverslip.

The samples were examined in transmitted illumination on the optical microscope at a magnification of 315X. Images of the particles to be sized were transferred via video camera to the television screen of the Le Mont OASYS Optical Analysis System. Equivalent circular diameters were automatically calculated on the image analyser. The smallest particle which could be measured at this magnification was 0.7 micrometre.

Representative photomicrographs were taken of each sample.

3. RESULTS

The size distribution data by frequency percent for samples #1 and #2 are given in Table 1 and 2 and are plotted as histograms in Figures 1 and 2.

Photomicrographs of the samples are shown in Figures 3 to 6. In sample #1, the oil droplets could not be distinguished from the suspended solids so the results are for all detected particles.

A summary of the data for the two samples is given in the following table.

	Particle Size (Micrometres)			
Sample	Average	RMS Deviation	Median	Range
#1	2.1	1.3	1.8	0.7-9
#2	2.5	1.5	2.3	0.7-15

A. J. Terry
Sr. Technologist
Inorganic Materials Centre

C. S. Gibbons, Ph.D
Manager
Inorganic Materials Centre

TABLE 1

SIZE DISTRIBUTION FOR #1 OIL IN WATER EMULSION

DIAMETER CLASS INTERVAL (MICROMETRES)	FREQUENCY	FREQUENCY PERCENT	CUMULATIVE FREQUENCY PERCENT
0.7 - 0.9	130	11.6	11.6
0.9 - 1.2	141	12.5	24.1
1.2 - 1.5	178	15.8	39.9
1.5 - 1.8	126	11.2	51.2
1.8 - 2.1	91	8.1	59.3
2.1 - 2.4	117	10.4	69.7
2.4 - 2.7	92	8.2	77.8
2.7 - 3.0	65	5.8	83.6
3.0 - 3.3	36	3.2	86.8
3.3 - 3.6	45	4.0	90.8
3.6 - 3.9	14	1.2	92.1
3.9 - 4.2	27	2.4	94.5
4.2 - 4.5	11	1.0	95.5
4.5 - 4.8	6	0.5	96.0
4.8 - 5.1	6	0.5	96.5
5.1 - 5.4	8	0.7	97.2
5.4 - 5.7	4	0.4	97.6
5.7 - 6.0	7	0.6	98.2
6.0 - 9.0	20	1.8	100.0
	1124		

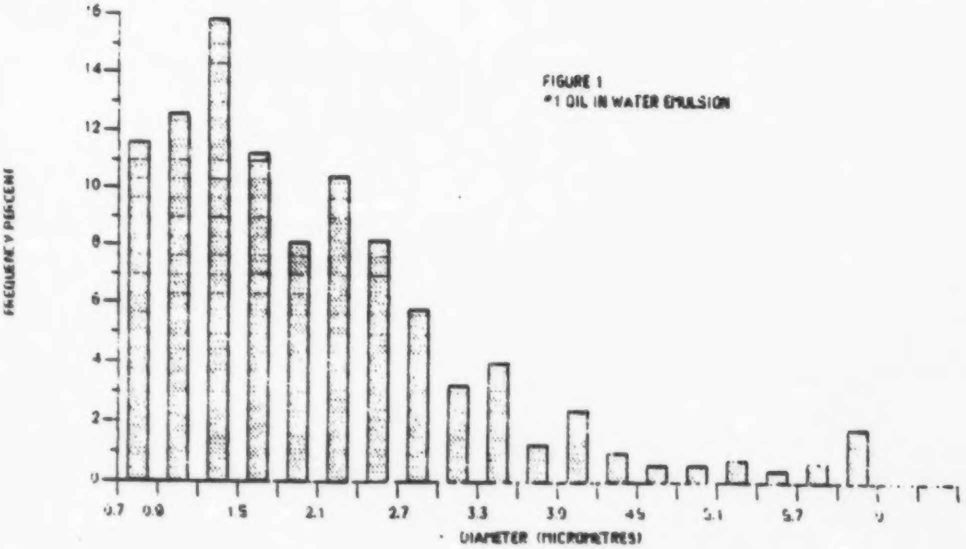

FIGURE 1
#1 OIL IN WATER EMULSION

TABLE II

SIZE DISTRUIBUTION FOR #2 WATER IN OIL EMULSION

DIAMETER CLASS INTERVAL (MICROMETRES)	FREQUENCY	FREQUENCY PERCENT	CUMULATIVE FREQUENCY PERCENT
0.7 - 1.0	441	9.7	9.7
1.0 - 1.5	672	14.7	24.4
1.5 - 2.0	681	14.9	39.3
2.0 - 2.5	942	20.6	59.9
2.5 - 3.0	663	14.5	74.5
3.0 - 3.5	346	7.6	82.1
3.5 - 4.0	251	5.5	87.6
4.0 - 4.5	179	3.9	91.5
4.5 - 5.0	116	2.5	94.0
5.0 - 5.5	74	1.6	95.6
5.5 - 6.0	49	1.1	96.7
6.0 - 6.5	37	0.8	97.5
6.5 - 7.0	34	0.7	98.3
7.0 - 7.5	15	0.3	98.6
7.5 - 8.0	17	0.4	99.0
8.0 - 8.5	13	0.3	99.3
8.5 - 9.0	4	0.1	99.3
9.0 - 9.5	6	0.1	99.5
9.5 - 10.0	5	0.1	99.6
10.0 - 15.0	19	0.4	100.0
	4564		

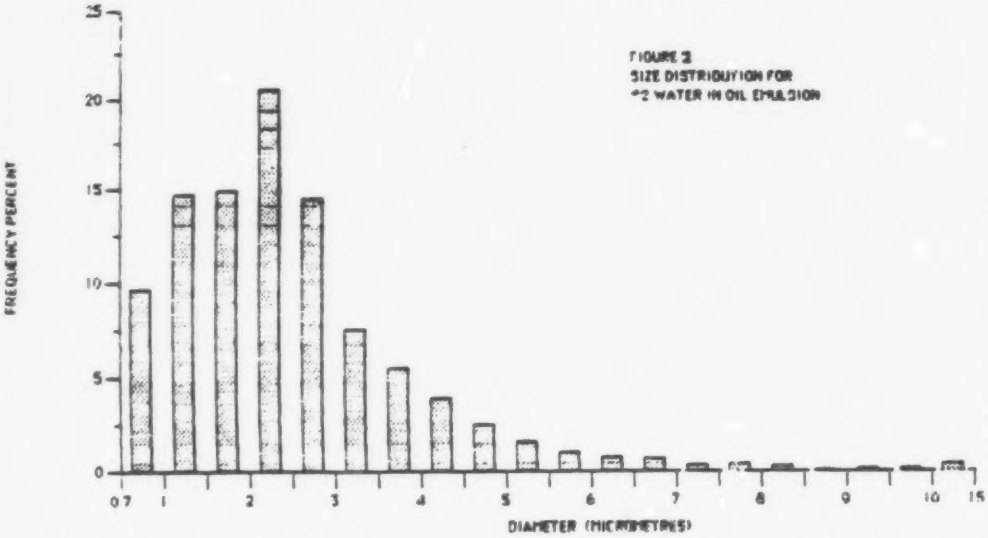

FIGURE 2
SIZE DISTRIBUTION FOR
#2 WATER IN OIL EMULSION

Figure 3: Sample #1 315X

Figure 4: Sample #1 315X

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Mr. R. A. Copley
Dept. BCE

January 26, 1989

REPORT NUMBER	IA 201-89-1
IDENTIFICATION	W.O. #2992
SPECIFICATIONS OF ORDER	**Particle Size Analysis of Zenon Emulsion**

I. INTRODUCTION

A sample identified as "Zenon Emulsion" was received for size particle distribution based on diameter by frequency percent. Representative photomicrographs were also required.

2. METHOD

The sample was shaken and several drops were transferred by pipet from the container to a microscope slide and a coverslip was set on top.

Terms and conditions on reverse.

It was examined in transmitted illumination on the optical microscope at a magnification of 315X. Images of the particles to be sized were transferred via video camera to the television screen of the LeMont OASYS Optical Analysis System. Equivalent circular diameters were automatically calculated on the image analyser. The smallest particle which could be measured at this magnification was 0.7 micrometres.

Representative photomicrographs were taken of each sample.

3. RESULTS

The size distribution data based on diameter size by frequency percent over the range of 0.7 to 21.3 micrometres are given in Table I and plotted as a histogram in Figure 1. The average and RMS deviation were 2.16 and 1.51 micrometres respectively and the median diameter was 1.98 micrometres. Photomicrographs of the sample can be found in Figure 3.

M. L. Petrovcic
Project Scientist
Inorganic Materials Centre

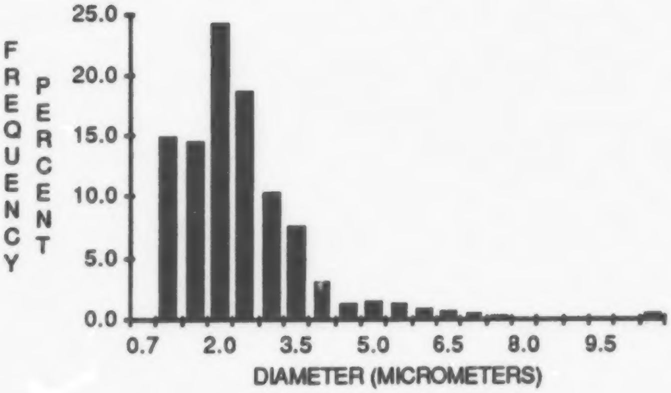
C. S. Gibbons
Manager
Inorganic Materials Centre

:mw

TABLE 1
SIZE DISTRIBUTION FOR
ZENON EMULSION

DIAMETER CLASS INTERVAL (MICROMETERS)	FREQUENCY	FREQUENCY PERCENT	CUMULATIVE FREQUENCY PERCENT
0.7	0	0.0	0.0
1.0	152	14.8	14.8
1.5	149	14.6	29.4
2.0	248	24.2	53.6
2.5	191	18.7	72.3
3.0	107	10.4	82.7
3.5	78	7.6	90.3
4.0	31	3.0	93.4
4.5	12	1.2	94.5
5.0	15	1.5	96.0
5.5	13	1.3	97.3
6.0	9	0.9	98.1
6.5	6	0.6	98.7
7.0	4	0.4	99.1
7.5	3	0.3	99.4
8.0	1	0.1	99.5
8.5	1	0.1	99.6
9.0	0	0.0	99.6
9.5	0	0.0	99.6
10.0	0	0.0	99.6
21.3	4	0.4	100.0
	1024		

FIGURE 1
SIZE DISTRIBUTION FOR
ZENON EMULSION



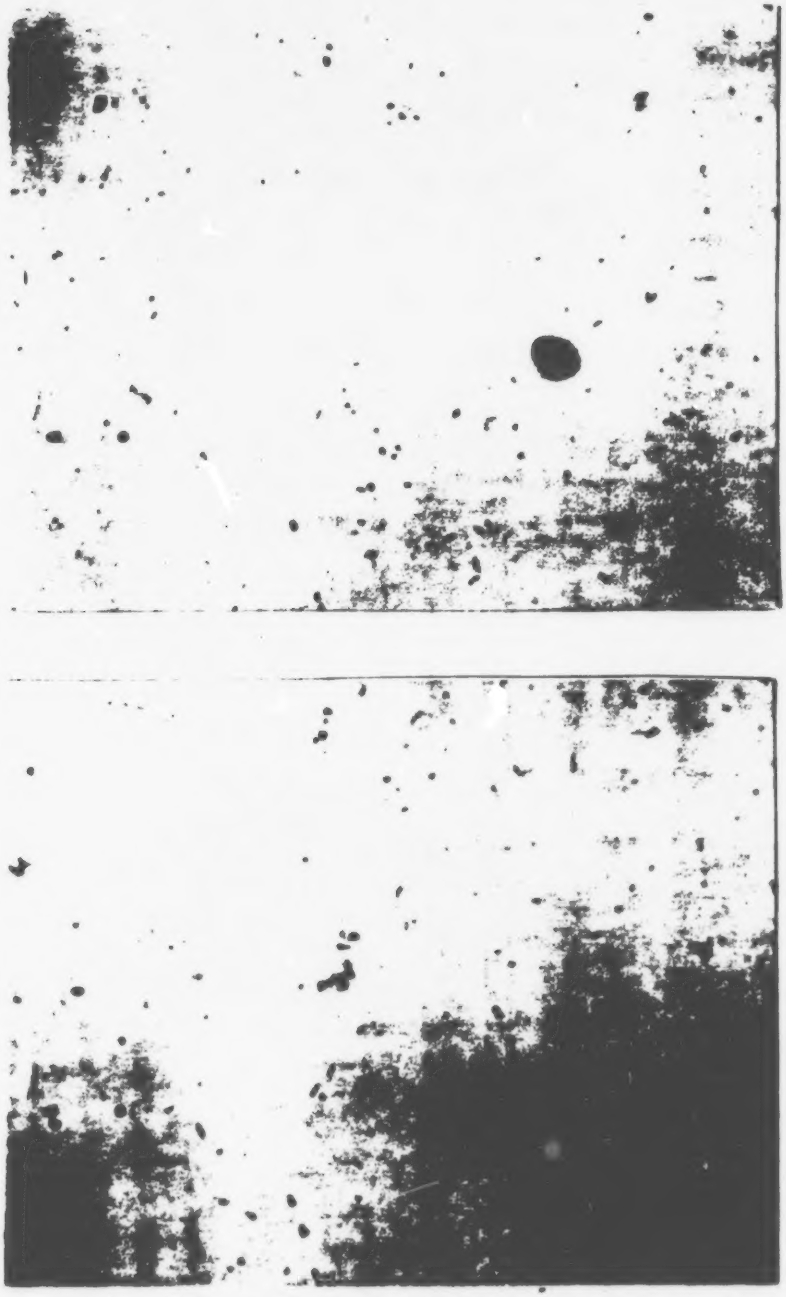


Figure 3: Zenon Emulsion 315X

TABLE F-2

Site "B," Skim Tank Influent Produced Water Characteristics With Changes in pH and Heat.

pH	TIME (hours)			
	1	5	24	FINAL (1 week)
Control (pH=7.87)	-brownish opaque solution; no floc; some ppt.	- fine ppt. ; slightly darker in colour - org/brw	-bottom coated in black ppt. ; clear brw. sol.	- vey dark in colour ; some some loss of volume due to evaporation
10	-same as control-except clearer orange colour	slightly less ppt. than control ; lighter orange in colour	-bottom coated in brw. ppt.; clear orange sol., lighter than above	-very similar to control except for a brown residue film floating on top
7.5	-darker than above - otherwise same as control	- slightly less ppt. than control ; darker in colour - brw	-ppt. same as control; clear grey sol.	- same as above
5.5	-some fine floc;lighter colour than pH 7.5 run; some ppt.	- slightly more ppt. than control; light olive/brw colour	-ppt. lighter brw. than above; clearer than above , olive/ grey colured	- same as above
4.5	- same colour as pH 7.5 run ; suspended floc.;	- same as above except cloudier - light floc	- same as above except more ppt.	- clear with a brownish tinge ; fully settled
3.5	- same as above except for a larger floc ; slightly more ppt. and lighter colour	- same as above -but heavier fl and heavier ppt.	-same as above except even lighter brw. ppt.	- clear ; greenish brown ppt. settled on bottom
3.3	- same as above except for less ppt.; larger floc ; colour same as pH 4.5 run	- same as above except for a slightly larger amt. of ppt.	- same as above except clearer, ppt. covered in fine greyish dust	- same as above
2.9	-same as above except larger floc; more ppt.	- same as above except for a heavier floc.	- same as above except clearer	- same as above
2.5	- same as above except for largest floc; lighter in colour (turbulence); heaviest ppt.	-same as above - but clearest	- same as above except clearest sample	- same as above

SAMPLES RECEIVED : The samples received were 2, 45 gal. drums of produced water from Site "B" (brown water with suspended solids)

pH ADJUSTMENT: ACID - HCL, BASE - NaOH

ADDITION : The heat stability of the produced water sample was also test The sample was heated at 100 °C. for 5 hours. There was some apparent change in the characteristics of the solution such as a ppt. forming when the solution settled and cooled to 80 deg. cel. After settling overnight the solution looked the same as the control.

February 3, 1989

Xenon Environmental Inc.
845 Harrington Court
Burlington, Ontario
L7N 3P3

Attention: Mr. Jim Imrie
Mr. Peter Filipowich

Report Number:	89-48-50006-009
Identification:	P.O. #C63261 PF (W.O. #2992)
Specification of Order:	Zeta Potential and Particle Size Analysis on an Emulsion

---

EXPERIMENTAL

The sample received was labelled; " Site "B" ; January 5, 1983".

The Zeta potential was measure by microelectrophoresis on a Lazer Zee Meter, Model 500. The pH of the specimen was also measured.

Particle Size analysis was carried out according to the appended report by our Fine Particle Analysis Group. Photomicrographs were also supplied.

RESULTS

On this sample the Zeta Potential was measured to be - 16.5 mev with a standard deviation of 3.0. The pH was 7.9.

In the particle size analysis, the average diameter was 2.16 μ, with an RMS deviation of 1.51, while the median diameter was 1.98 μ. The full report is attached.

Rick Copley

R. Copley, B.Sc.
Forest Products Services
Biotechnology & Chemical
Engineering Centre

RC/vp

Enc.

Zenon Environmental Inc.
845 Harrington Court
Burlington, Ontario
L7N 3P3

Attention: J.R. Imrie

February 14, 1990

REPORT NO: IA 306-90-002

IDENTIFICATION: P.O. # C66233-JI

SPECIFICATIONS OF ORDER: Zeta Potential and Particle Size Analysis of Oil Emulsion

---

1. INTRODUCTION

A sample of an oil emulsion was received for zeta potential analysis and particle size analysis based on diameter size by frequency percent. The sample was identified as follows:

ORTECH I.D.	CLIENT I.D.
90-66-I0022	Site "6" Oil January

The zeta potential analysis is included as appendix A. The particle size analysis is presented in the following sections of this report.

2. METHOD

The sample was shaken and a few drops of the mixture were placed on a microscope slide and a coverslip was set on top. The sample was viewed in transmitted illumination on the optical microscope at a magnification of 315X. Images of the particles were transferred via the video camera to the television monitor of the LeMont OASYS Optical Analysis System. Equivalent circular diameters of the particles were automatically calculated by the image analyzer.

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Mississauga, Ontario L5K 1B3
(416) 822-4111
Telefax (416) 823-1446

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5. Our name shall not be used in any way in connection with the sale, offer or advertisement of any article, process or service.
6. We reserve the right not to commence and/or continue any work until payment arrangements satisfactory to us are established.

3. RESULTS

The size distribution data based on diameter size by frequency percent over the range of 0.7 to 39.9 are given in Table 1 and plotted as a histogram in Figure 1. The average and RMS deviation were 2.56 and 2.23 respectively, and the median diameter is 2.27 micrometers. Photomicrographs of the sample are shown in Figure 2.

VTrimble
Virginia R. Trimble
Image Analysis
Biotechnology & Chemical
Engineering

Martin L. Petrovcic
Image Analysis
Biotechnology & Chemical
Engineering

TABLE 1
SIZE DISTRIBUTION FOR
Site "B" JANUARY

DIAMETER CLASS INTERVAL (MICROMETRES)	FREQUENCY	FREQUENCY PERCENT	CUMULATIVE FREQUENCY PERCENT
0.7	0	0.0	0.0
1.0	106	9.6	9.6
1.5	156	14.2	23.8
2.0	168	15.3	39.1
2.5	218	19.8	59.0
3.0	205	18.7	77.6
3.5	89	8.1	85.7
4.0	59	5.4	91.1
4.5	35	3.2	94.3
5.0	14	1.3	95.5
5.5	12	1.1	96.6
6.0	4	0.4	97.0
6.5	4	0.4	97.4
7.0	4	0.4	97.7
7.5	3	0.3	98.0
8.0	2	0.2	98.2
8.5	3	0.3	98.5
9.0	1	0.1	98.5
9.5	2	0.2	98.7
10.0	1	0.1	98.8
15.0	7	0.6	99.5
20.0	3	0.3	99.7
30.0	1	0.1	99.8
40.0	2	0.2	100.0
	1099		

FIGURE 1
SIZE DISTRIBUTION FOR
Site "B" JANUARY

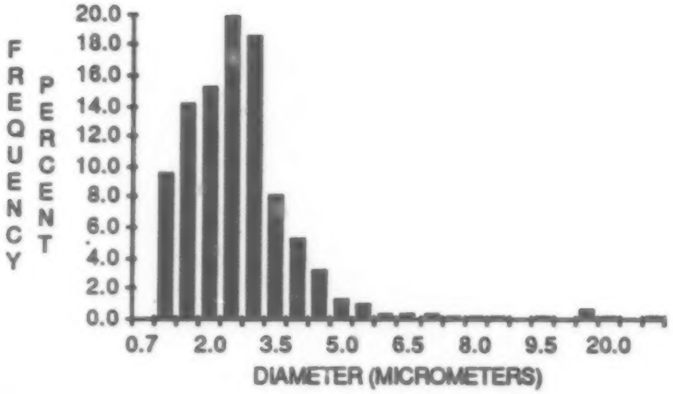

FIGURE 2
Site "B" Produced H_2O
January Sample
Magnification: 315X

Appendix A:

Zeta Potential Analysis

ORTECH
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Telefax (416) 823-1446

Ms V. Trimble
Fine Particle Laboratory

February 9, 1990.

Report Number	FP - 028
Identification	W.O. # 5822
Specifications of Order	Zeta Potential on Xenon Emulsion

The sample of oil emulsion labelled " Site"B" - January" was tested for zeta potential using a Model 501 Lazer Zee zetameter.

The sample was agitated and an aliquot removed for testing. The aliquot was then tested for pH and a portion of it used for the charge measurement.

Results:

The zeta potential was measured on the majority of the particles in the field. There was, however, a small proportion of particles which exhibited much smaller charges (closer to 0.0, but still negative).

The results on this matrix at pH 7.6 (as is) were:

$$Z.P. = -15.7 \text{ mev}$$
$$\sigma = \pm 1.7 \text{ mev}$$

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6. We reserve the right not to commence and/or continue any work until payment arrangements satisfactory to us are established.

APPENDIX G

Ultrafiltration Equipment and Operation

Hazardous Locations
Ultrafiltration Unit

LEGEND

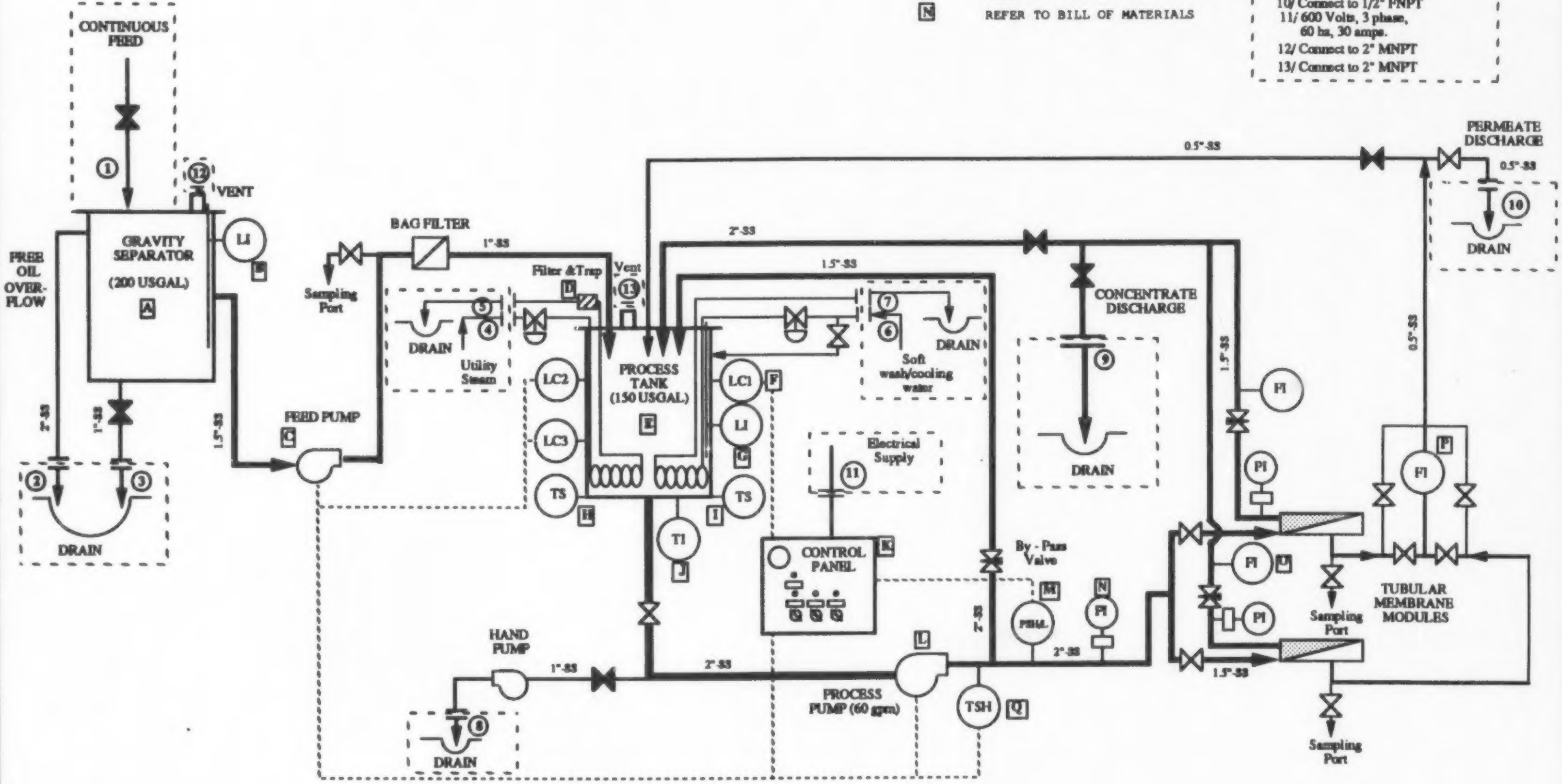
INSTRUMENTATION KEY

FI	FLOW INDICATOR (ROTOMETER)
PI	PRESSURE INDICATOR
LC	LEVEL CONTROL
TI	TEMPERATURE INDICATOR
LI	LEVEL INDICATOR
TSH	TEMPERATURE SWITCH HIGH
PSH/L	PRESSURE SWITCH (HIGH/LOW)
TS	TEMPERATURE SENSOR
N	REFER TO BILL OF MATERIALS

REQUIRED FIELD CONNECTIONS

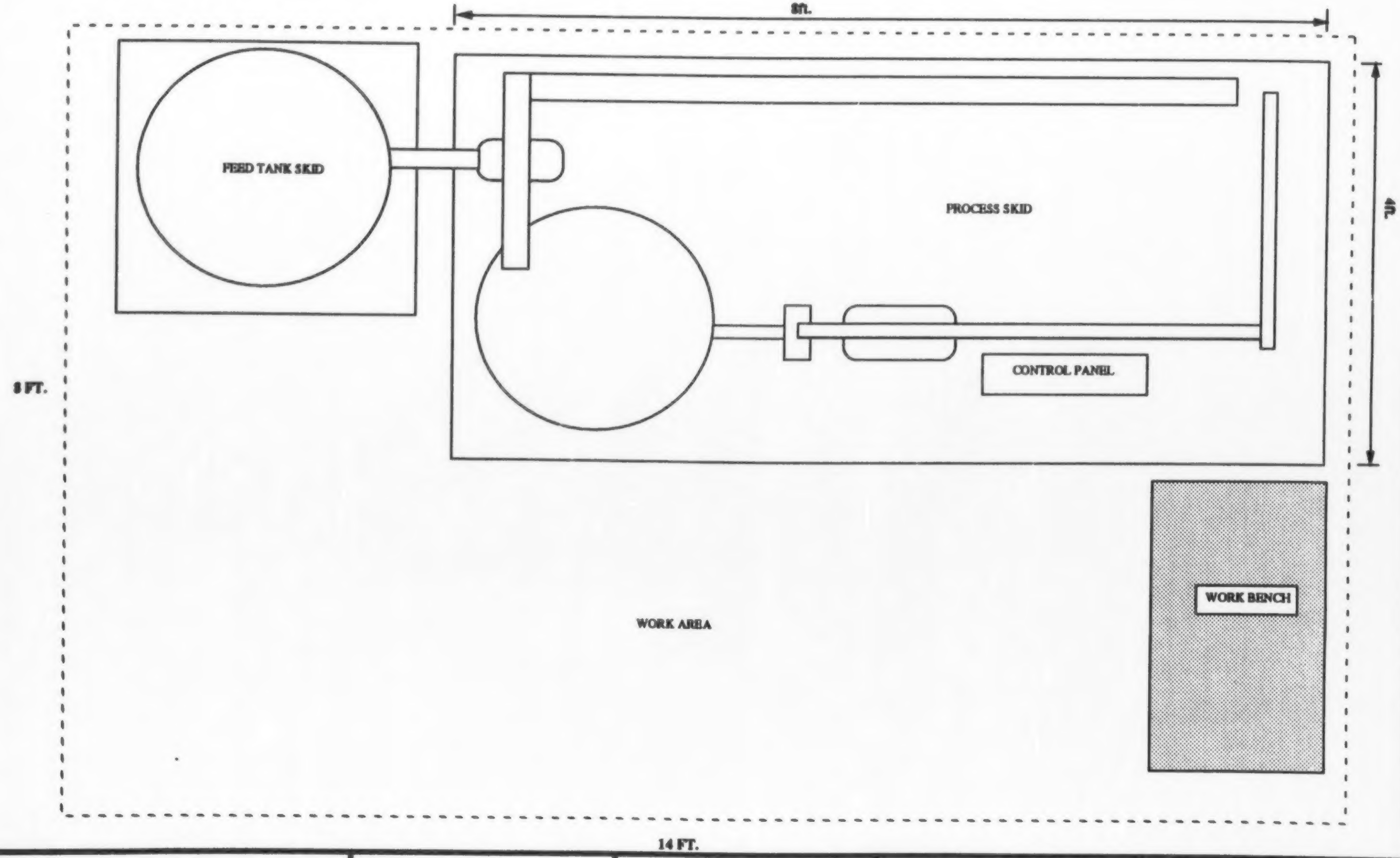
1/ Connect to 1 1/2" MNPT
2/ Connect to 2" MNPT
3/ Connect to 1" MNPT
4/ Connect to 1/2" FNPT
5/ Connect to 1/2" FNPT

6/ Connect to 1/2" FNPT
(Min. 5 USGPM)
7/ Connect to 1/2" FNPT
8/ Connect to 1" MNPT
9/ Connect to 1 1/2" FNPT
10/ Connect to 1/2" FNPT
11/ 600 Volts, 3 phase,
60 hz, 30 amps.
12/ Connect to 2" MNPT
13/ Connect to 2" MNPT


CONTINUOUS FEED
①
⑫ VENT
GRAVITY SEPARATOR
(200 USGAL)
A
LI
B
FREE OIL OVER-FLOW
2"-SS
1"-SS
②
③
DRAIN
1.5"-SS
FEED PUMP
C
Sampling Port
BAG FILTER
1"-SS
Filter & Trap
D
Vent
⑬
⑤
④
DRAIN
Utility Steam
PROCESS TANK
(150 USGAL)
E
LC2
LC3
TS
H
LC1
F
LI
G
TS
I
TI
J
2"-SS
1.5"-SS
⑦
⑥
DRAIN
Soft wash/cooling water
Electrical Supply
⑪
CONTROL PANEL
K
CONCENTRATE DISCHARGE
⑨
DRAIN
By - Pass Valve
M
PSH/L
N
PI
2"-SS
HAND PUMP
1"-SS
⑧
DRAIN
2"-SS
PROCESS PUMP (60 gpm)
L
TSH
Q
0.5"-SS
PERMEATE DISCHARGE
0.5"-SS
⑩
DRAIN
1.5"-SS
0.5"-SS
FI
PI
FI
P
FI
O
PI
Sampling Port
TUBULAR MEMBRANE MODULES
1.5"-SS
Sampling Port

ZENON ENVIRONMENTAL INC. Burlington Ont.	DRAWN	JRI	DATE June 13, 1988	CHECKED	PJC	APPROVED	PJC
	CUSTOMER	Process Engineering Group, ZEI				CONTRACT #	-
	TITLE	Hazardous Locations Ultrafiltration Unit: P&ID				DRAWING #	001

Hazardous Locations Ultrafiltration Unit

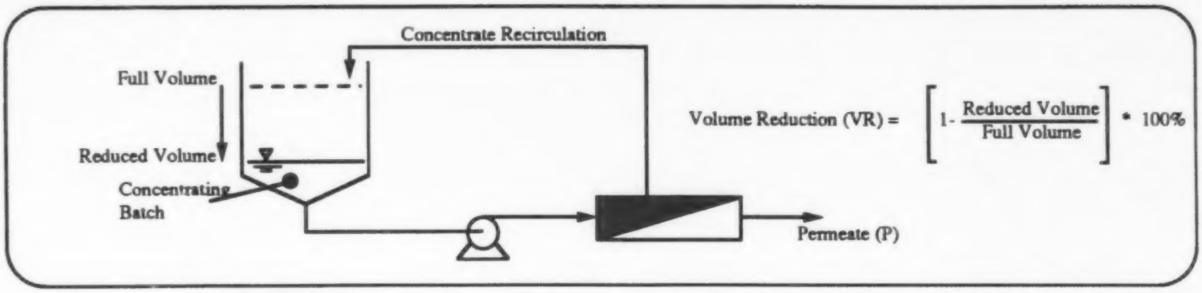

8ft.
4ft.
8 FT.
14 FT.
FEED TANK SKID
PROCESS SKID
CONTROL PANEL
WORK BENCH
WORK AREA

ZENON ENVIRONMENTAL INC.
Burlington Ont.

DRAWN JRI	DATE February 19, 1988	CHECKED PJC	APPROVED PJC
CUSTOMER Process Engineering Group, ZEI			CONTRACT # -
TITLE Hazardous Locations Ultrafiltration Unit: Equipment Layout			DRAWING # 003

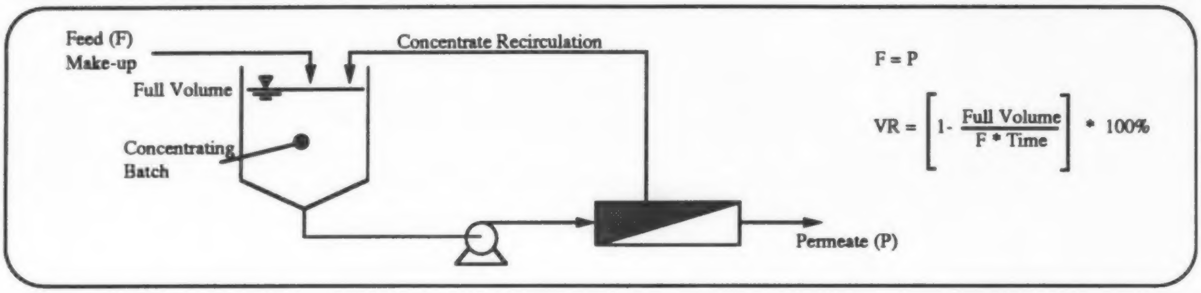
Membrane Filtration Processing Options

Regular Batch Mode (RBM)


Concentrate Recirculation
Full Volume
Reduced Volume
Concentrating Batch
Permeate (P)

$$\text{Volume Reduction (VR)} = \left[1 - \frac{\text{Reduced Volume}}{\text{Full Volume}}\right] * 100\%$$

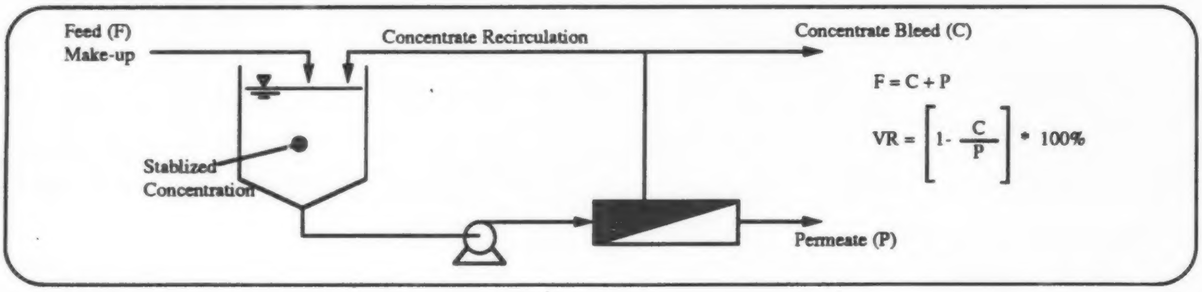
Modified Batch Mode (MBM)


Feed (F) Make-up
Concentrate Recirculation
Full Volume
Concentrating Batch
Permeate (P)

$$F = P$$

$$VR = \left[1 - \frac{\text{Full Volume}}{F * \text{Time}}\right] * 100\%$$

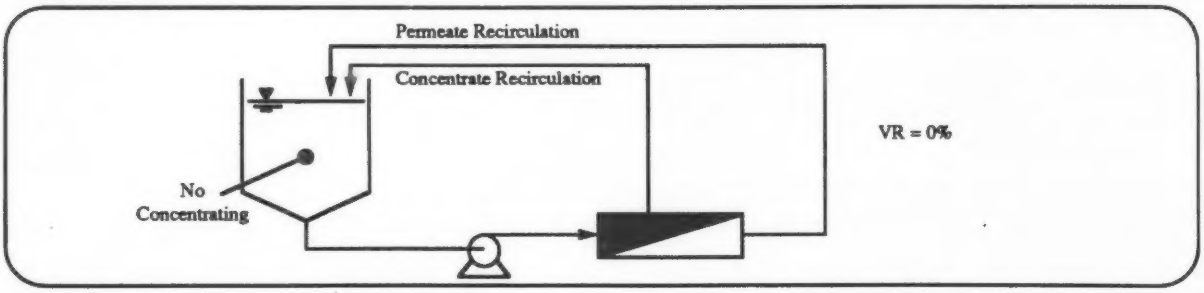
Feed & Bleed Mode (FBM)


Feed (F) Make-up
Concentrate Recirculation
Concentrate Bleed (C)
Stablized Concentration
Permeate (P)

$$F = C + P$$

$$VR = \left[1 - \frac{C}{P}\right] * 100\%$$

Stability Mode


Permeate Recirculation
Concentrate Recirculation
No Concentrating

$$VR = 0\%$$

ZENON Environmental Inc.

APPENDIX H

Cost Breakdown of Conventional and Membrane Based Treatment Processes

CONVENTIONAL OIL REMOVAL PROCESS
CAPITAL COSTS OF INDIVIDUAL COMPONENTS

Skim Tank System	$161,432
IGF System	$193,300
Sand Filter System	$103,300
TOTAL PROCESS COSTS	$458,032

CONVENTIONAL OIL REMOVAL PROCESS
TOTAL COST OF INSTALLED EQUIPMENT

Purchase Cost of Equipment	$458,032		
Shipping Charges	$36,643		
Installation of Equipment	$91,606		
Foundations	$77,865		
Instruments	$64,124		
Piping	$114,508		
Insulation	$77,865		
Electrical	$91,606		
Building and Structures	$45,803		
Services	$54,964		
Misc.	$45,803		
TOTAL DIRECT COSTS		$1,158,821	
Construction and Field Expences	$115,882		
Engineering Expences	$92,706		
Contractors Fees	$68,370		
Contingencies	$136,741		
TOTAL INDIRECT EXPENCES		$413,699	
TOTAL COSTS			$1,572,520

CONVENTIONAL OIL REMOVAL PROCESS
OPERATING COSTS

MATERIALS (Demulsifying Chemicals)		
Skim Tank (10 ppm @ $13.25/gal.)	$24,181	
IGF (5 ppm @ $22.71/gal.)	$20,723	
Sand Filter (50 ppm @ $13.25/gal.)	$120,906	
LABOUR (equipment supervision and filter backwash)		
Skim Tank (2/3 shift / day, @$100,937/shift/yr.)	$67,291	
IGF (2/3 shift / day, @$100,937/shift/yr.)	$67,291	
Sand Filter (2/3 shift / day, @$100,937/shift/yr.)	$67,291	
ENERGY		
Skim Tank (15 HP)		
IGF (35 HP)		
Sand Filter (5 HP)		
(55 HP X 0.7457 X 24 X 365 X 3.66 cents/KW)	$13,150	
CONTINGENCIES & MAINTENANCE		
Other Operating Expences (15 % of other expences)	$53,498	
TOTAL OPERATING COSTS		$434,331

TUBULAR MEMBRANE SYSTEM COST

Flux Rate (gfd)	100	
Number of Systems	3	
Membrane Costs	270/m^2	
COST PER SYSTEM		$144,867
TOTAL COST		$434,602

MEMBRANE BASED OIL REMOVAL PROCESS
OPERATING COST OF EQUIPMENT

MATERIALS		
Membrane Cleaning Chemicals ($13.50/lb, 10 lb per 500 gal. soln., 52 cleans per yr.)	$21,060	
Replacement Membranes (every 2 years)	$64,313	
LABOUR		
Supervision of Equipment and Cleaning (1 shift per day)	$100,937	
ENERGY		
Membrane Pump (3 X 50 HP) Skim Tank Pump (15 HP) (165 HP X 0.7457 X 24 X 365 X 3.66 cents/KW)	$39,449	
CONTINGENCIES & MAINTENANCE		
Other Operating Expences (20 % of other expences)	$45,152	
TOTAL OPERATING COSTS		$270,910

MEMBRANE BASED OIL REMOVAL PROCESS
TOTAL COST OF INSTALLED EQUIPMENT

Purchase Cost of Membrane System	$434,602		
Purchase Cost of Skim Tank	$161,432		
Shipping Charges	$29,802		
Installation of Equipment	$47,683		
Foundations	$29,802		
Instruments	$35,762		
Piping	$71,524		
Insulation	$59,603		
Electrical	$71,524		
Building and Structures	$59,603		
Services	$47,683		
Misc.	$29,802		
TOTAL DIRECT COSTS		$1,078,821	
Construction and Field Expences	$53,941		
Engineering Expences	$64,729		
Contractors Fees	$59,875		
Contingencies	$119,749		
TOTAL INDIRECT EXPENCES		$298,294	
TOTAL COSTS			$1,377,115